US Army Corps of Engineers
Nashville District

WOLF CREEK DAM/LAKE CUMBERLAND

EMERGENCY MEASURES
IN RESPONSE TO SEEPAGE

FINAL ENVIRONMENTAL IMPACT STATEMENT

December 2007

WOLF CREEK DAM/LAKE CUMBERLAND, KENTUCKY
EMERGENCY MEASURES
IN RESPONSE TO SEEPAGE
FINAL ENVIRONMENTAL IMPACT STATEMENT

Responsible Federal Agency:
U.S. Army Corps of Engineers

Cooperating Agencies:
U.S. Fish and Wildlife Service
Tennessee Valley Authority

Alternatives:
(1) No Action (i.e. maintain normal operational guidelines).
(2) Maintain Lake Cumberland pool height at 680 ft.
(3) Maintain Lake Cumberland pool height at 650 ft.
(4) Maintain Lake Cumberland pool height within an operating band between 685 and 700 ft.
(5) Manage the Cumberland River system in accordance with an Interim Operating Plan.
(6) Maintain Lake Cumberland pool height at 610 ft.
(7) Construct a new roller-compacted dam downstream of the existing dam.

Location:
South Central Kentucky and Central Tennessee

Abstract:
Wolf Creek Dam is located at CRM 460.9 near Jamestown, Kentucky. The combination concrete and earthen embankment dam was designed and built in the 1940's and 1950's. The entire Project was completed in 1952. The dam impounds the largest flood control reservoir east of the Mississippi River and is owned and operated by the U.S. Army Corps of Engineers, Nashville District (Corps). The six-generator unit hydroelectric plant located immediately downstream has a total capacity of 270,000 kilowatts (kW). Lake Cumberland, impounded by the dam, has a drainage area of 5,789 square miles. The lake impounds 6,089,000 acre-feet at its maximum flood control pool elevation (EL, National Geodetic Vertical Datum of 1929, commonly referred to as feet above mean sea level) EL 760. The concrete dam and earthen embankment have been plagued with increasing seepage problems since construction of the dam. An Environmental Assessment was completed in 2005 to address seepage repairs and a Finding of No Significant Impact was executed. At that time, no significant changes to the customary pool elevations were considered necessary. However, repairs will take a number of years to implement. In January 2007, the Corps made the decision to lower Lake Cumberland to elevation 680 ft immediately and to hold that elevation for an indefinite period; unless and until the Corps determines that a different pool elevation is more appropriate. The purpose of this Environmental Impact Statement is to evaluate impacts due to lowering the pool elevation to 680 ft, an Interim Operating Plan for the Cumberland River Reservoir System, a new roller compacted concrete dam, and other alternative pool elevations including extreme elevation changes that could occur during the 5-7-year repairs of the dam's foundation and abutments. This document is a part of the alternative arrangements, negotiated with the President's Council for Environmental Quality, for National Environmental Policy Act compliance.

For additional information or to send review comments, contact: Mr. Chip Hall, Project Planning Branch, U.S. Army Corps of Engineers, P.O. Box 1070, Nashville, Tennessee 37202-1070, (615) 736-7666; e-mail Lake.Modification@Lrn02.usace.army.miL.

EXECUTIVE SUMMARY

Wolf Creek Dam is located at CRM 460.9 near Jamestown, Kentucky. The Wolf Creek project was constructed by the US Army Corps of Engineers (Corps) and has been in service for 55 years (1952-2007) providing important benefits of flood control, hydropower, recreation, water supply, water quality, fish and wildlife. The dam is 258 feet high and consists of a combination earth fill and concrete structure 5,736 feet long. Wolf Creek has six 45-megawatt (MW) turbines, for a total capacity of 270-MW. US Highway 127 traverses the top of the dam. Lake Cumberland, created by the dam, impounds 6,089,000 acre-ft at its maximum pool elevation National Geodetic Vertical Datum of 1929 (ft), 760 ft. All project uses except flood control, are drawn from the power pool located between elevations 673 ft and 723 ft. Under normal operations, the maximum summer pool elevation is 723 ft, and the minimum winter pool elevation is 695 ft.

Since construction, seepage problems through the karst limestone foundation have required diligent monitoring, subsurface investigations and grouting. Foundation conditions have deteriorated because clay-filled joints in the rock within the rims and dam foundation are eroding. This chronic erosion jeopardizes the earthen embankment resulting in a high potential for dam failure. Wolf Creek Dam is ranked in Dam Safety Action Classification I -- the highest category of risk and urgency for dam safety major rehabilitation. A report titled, Wolf Creek Dam, Jamestown, Kentucky, Seepage Control Major Rehabilitation Evaluation Final Report, 11 July 2005, evaluated seepage problems and provided justification for a major rehabilitation project at Wolf Creek Dam. The report also contains an Environmental Assessment that considered different dam repair alternatives. The repair alternative selected will use a combination concrete cutoff wall along the full length of the embankment and a triple line grout curtain.

Failure of Wolf Creek Dam would be catastrophic. Loss of life is expected to exceed one-hundred lives. Economic losses are estimated in the billions with damages as distant as Nashville, Tennessee expected to exceed $2 billion. A Memorandum for Record with the subject line "Wolf Creek Dam Interim Risk Reduction Measures" was signed on 19 January 2007. This document outlined the decision to lower Lake Cumberland to elevation 680 ft immediately and to hold that elevation for an indefinite period, unless and until the Corps determines that a different pool elevation is more appropriate.

The Corps believed that the need for action regarding the Wolf Creek Dam was so urgent and compelling that there was no time to follow the usual National Environmental Policy Act (NEPA) procedures before the Corps made decisions and began to implement them. The Corps, therefore, invoked its authority under 33 CFR 230.8 "Emergency Actions", and declared an emergency, made decisions, and took necessary actions accordingly. Completion of an environmental assessment or environmental impact statement was impracticable prior to the Corps' making essential decisions and initiating emergency work to prevent dam failure. Consequently, pursuant to 33 CFR 230.8 and 40 CFR 1506.11, the Corps, in a letter dated 18 January 2007, sought to initiate consultation with the President's Council on Environmental Quality (CEQ) regarding alternative arrangements for National Environmental Policy Act (NEPA) compliance.

As part of those arrangements, steps that were taken to address the emergency included the implementation of a comprehensive communication plan, establishment of a working group to advise the Corps on the appropriate engineering and scientific steps needed to deal with the problem, coordination with the U.S. Fish and Wildlife Service (USFWS) pursuant to the Endangered Species Act (ESA), the Fish and Wildlife Coordination Act, and other relevant authorities, and coordination with the EPA and other appropriate Federal, state, and local agencies. Also in accordance with the alternative arrangements, the Corps issued a Notice of Intent (issued 2 February 2007) to prepare an EIS and would complete either a full-scale EIS or the nearest approximation thereof that the circumstances would allow (the NEPA document). The NEPA document would address the Corps' existing and future efforts to preserve, repair, strengthen, and operate the Wolf Creek Dam and Lake Cumberland, including mitigation measures that could be implemented to minimize adverse effects from lowered lake levels and other measures.

This Environmental Impact Statement (EIS) is the result of those alternative arrangements. Seven alternatives are considered in the EIS:

1. No Action (i.e. maintain normal operational guidelines.
2. Maintain Lake Cumberland pool height at 680 ft.
3. Maintain Lake Cumberland pool height at 650 ft.
4. Maintain Lake Cumberland pool height within an operating band between 685 and 700 mean sea level.
5. Manage the Cumberland River system in accordance with an Interim Operating Plan.
6. Maintain Lake Cumberland pool height at 610 ft.
7. Construct a new roller-compacted dam downstream of the existing dam.

Alternatives 1-5 are evaluated in detail, while alternative 6 and 7 were eliminated for various reasons.

Major Conclusions of this EIS are that lowering the Cumberland Lake pool elevation from normal operations significantly impacts many environmental resources. The level of severity will be primarily dependant on the weather and the specific pool elevation targeted. Due to the emergency nature of the dam's integrity, Alternative 2, maintain Lake Cumberland pool height at 680 ft and Alternative 5, manage the Cumberland River system in accordance with an Interim Operating Plan, have already been chosen for the current interim emergency period and are being carried out. It should be noted that Alternative 2 is specific to the management of Wolf Creek Dam/Lake Cumberland and Alternative 5 is a Cumberland Reservoir System wide management plan. Elevation 680 ft was the lowest point, to which the lake could be lowered, in which additional risks to human health and safety were not imposed. The environmentally preferred plan would be to continue to operate with the existing guide curve (no action); however, the consequences of a dam failure are so enormous that they outweigh the anticipated negative impacts to the environment. The recommended plan for future interim operation during the time of seepage repairs is to continue to operate the Cumberland Reservoir system in accordance to the Interim Operating Plan and to target a pool elevation of 680 ft at Lake Cumberland unless and until the Corps determines that a different pool elevation level is more appropriate. Mitigation for significant adverse impacts of lowering Lake Cumberland to and targeting a constant pool elevation of 680 ft. is the following:

1. Installation of an Orifice Gate. To provide minimum oxygenated water flow below Wolf Creek Dam an orifice gate can be installed over a sluice gate. Installation of one orifice gate at Wolf Creek Dam was completed on 24 October 2007. Stream flow measurements made shortly after the gate was installed indicated a discharge of approximately 280 cubic feet per second when the lake is at about elevation 679 feet. A second orifice gate is planned. Once both gates are in place a discharge of approximately 500 CFS should be achieved.
2. Blending turbine and sluice gate discharges. Water released through sluice gates, with Dissolved Oxygen (DO) levels as high as 10 mg/l, would be mixed with water released through hydropower generation that tends to have low DO. This will help to raise DO levels in the tailwater below Wolf Creek Dam. This action is already being used to reduce water quality impacts.
3. Supplement water flows from other tributary lakes. Excess water could be stored in other tributary reservoirs, such as Dale Hollow, J. Percy Priest, etc., to be slowly released over the summer to mitigate reduced flows from Wolf Creek Dam. This action is already being used to reduce impacts to the Cumberland River System.
4. Spilling water through tainter gates. During summer months, if water quality decreases, water can be spilled through the tainter gates on mainstem projects, such as Old Hickory Dam. This will help to raise DO in times of need. This action is already being used to reduce impacts to DO.
5. Aquatic Habitat Improvement. Funding and approval has been requested to construct aquatic habitat structure within Lake Cumberland while lake levels are lowered. Should funding be approved and received, consultation with Kentucky Department of Fish and Wildlife Resources to determine designs and locations of habitat structure will be initiated.
6. Recreation Improvements. Lowering user fees, extending boat ramps, processing requests for marina relocation, making improvements at Kendall Campground, extending open dates for recreation areas, and waiving rent for marina concessionaires are all ways to mitigate impacts to recreation. Many of these actions have already been carried out to reduce and mitigate impacts to recreation.
7. Supplemental tailwater intake for Wolf Creek National Fish Hatchery. The Corps has designed and installed a temporary intake that withdraws cooler water from the tailwater downstream of Wolf Creek Dam in order to supplement the hatchery's existing intake upstream of the dam. This would help reduce water temperature impacts of a lowered Lake Cumberland, to the hatchery's water supply. This system went into operation on August 7, 2007. Recently an alarm system was installed to alert Corps and USFWS personnel in the event of a pump failure. Wolf Creek Dam's control room is staffed at all times. Should there be a pump failure, the second pump would be started manually.
8. Mitigation for impacts to Historic Properties. The Nashville District has proposed that adverse effects to historic properties be addressed by stipulations within a Programmatic Agreement (PA) amongst the Corps of Engineers, the Advisory Council on Historic

Preservation, and the Kentucky State Historic Preservation Officer; relevant Native American tribes would be invited to concur in the agreement.

9. Public Communication. Interested parties will be kept informed of current information regarding all aspects of the Wolf Creek seepage rehabilitation construction project. Current information is kept up to date on the Corps, Nashville District website. The web address for that site is: http://www.lrn.usace.army.mil/WolfCreek/. Information will be maintained at this address for the duration of the construction project.

TABLE OF CONTENTS

APPENDICES

TABLES

FIGURES

1.0. Purpose And Need For Action

1.1. Authority.

The Flood Control Act of 1938 authorized construction of the Wolf Creek Dam. Supplementing authorizations were the Third Supplemental Defense Act of 1941, the Flood Control Act of 1944, and the River and Harbor Act of 1946. Section 4 of the Flood Control Act of 1944 authorized the US Army Corps of Engineers (Corps) to construct, maintain, and operate public park and recreational facilities and to permit construction, maintenance and operation of such facilities. The Federal Water Project Recreation Act of 1965 established development of the recreational potential at federal water resource projects as a full project purpose. The Fish and Wildlife Coordination Act (16 USC 661) and the Fish and Wildlife Conservation Act of 1980 (16 USC §§ 2901 – 2911) recognized "…the vital contribution of our wildlife resources to the Nation…" and provided that "…wildlife conservation shall receive equal consideration and be coordinated with other features of water-resource development programs…" The Clean Water Act (33 U.S.C. 1252 § 102(b)) added water quality to the Corps' mission at water-resource development projects. The River and Harbor Act of 1958 (43 U.S.C. 390b), authorizes the Secretary of the Army to include municipal and industrial water storage in Corps projects and to reallocate storage in existing projects to municipal and industrial water supply.

The current authorized project purposes are flood control, hydropower generation, recreation, fish and wildlife management, and water quality. Although, not specifically authorized for the purpose, the dam also makes some ancillary contribution to navigation, particularly on the lower Ohio and Mississippi Rivers. Also, water supply is not an authorized purpose, however, there are a number of water intakes on Lake Cumberland.

The National Environmental Policy Act (NEPA) of 1969, as Amended, requires that prior to making any decision that would entail any irreversible and irretrievable commitment of resources, a Federal agency shall consult with and obtain the comments of any Federal agency which has jurisdiction by law or special expertise with respect to any environmental impact involved, and shall solicit public input and comment. The Corps, however, has the authority in cases of emergency to take immediate action under the conditions set forth under 30 CFR 230.8. In such a situation, the Corps would consult the President's Council on Environmental Quality (CEQ) regarding alternative arrangements under NEPA pursuant to 40 CFR 1506.11. This document is a part of the alternative arrangements, negotiated with the CEQ, for NEPA compliance.

1.2. Background.

Wolf Creek Dam is a significant feature of the Cumberland River Basin. It was originally justified on the basis of flood damage reduction and hydropower production, although other authorized purposes have since been added. Figure 1 shows the locations of the dam as well as major potential flood damage centers.

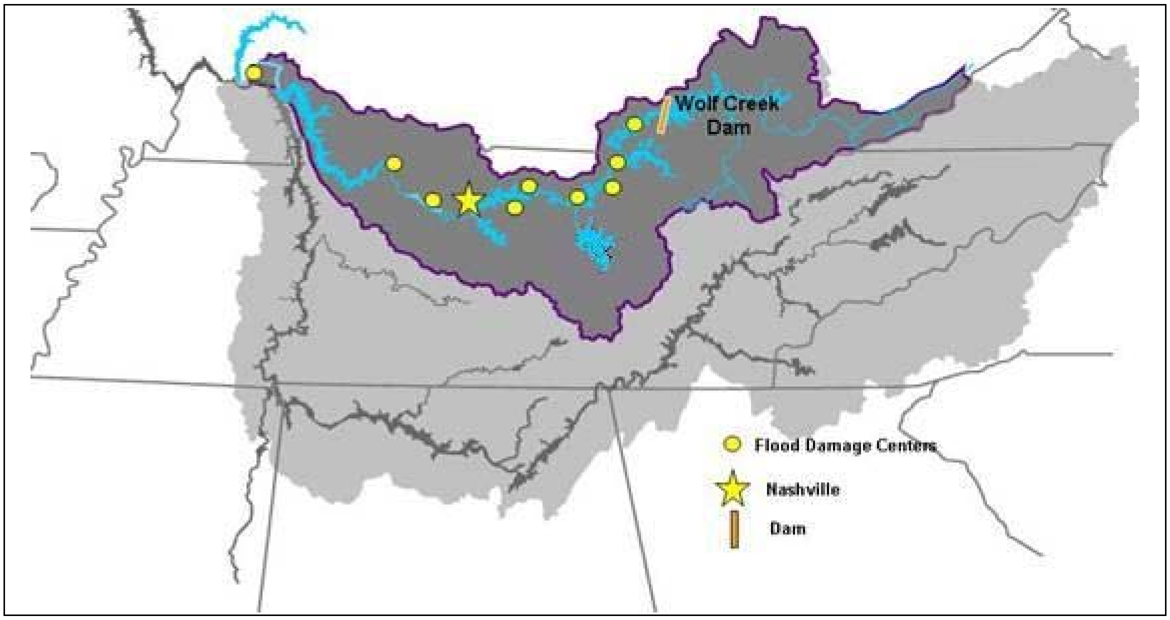


Figure 1 – The Cumberland River Basin

Wolf Creek Dam is a large, high head dam located near Jamestown, Kentucky at CRM 460.9 (see Figure 1). It controls runoff from a drainage area of approximately 5,789 square miles. The dam is a combination earth fill and concrete structure 5,736 feet long and 258 feet high, with a gated spillway structure. Construction began in August 1941, and was delayed for three years by World War II. The dam was completed for full use in August 1952.

1.2.1. Normal Dam Operation. The hydropower pool for Wolf Creek Dam extends from the top of the conservation pool elevation of 673 ft to 723 ft. The flood control pool extends from 723 to 760 ft. There is a seasonal operating guide within the power pool commonly referred to as the "SEPA power marketing zone" but is more accurately called the "Power Marketing Band" (PMB) in this document. SEPA is the acronym for the Southeastern Power Administration which is the Federal entity responsible for marketing the power generated by all Corps projects in the Nashville District. This operating zone was developed by SEPA, Tennessee Valley Authority (TVA) and the Corps. The power marketing band starts the year low in the power pool, fills through the spring reaching the top of the power pool by summer, and then gradually falls through the summer and fall, to approximately elevation 683 ft in time for the flood season. This is a non-binding operating guide that maximizes hydropower benefits while also supporting flood control, water quality, navigation, and other downstream uses dependent on the release of stored water through the summer and fall. The normal operation at Wolf Creek is to favor the top of the PMB, targeting a June 1 elevation of 723 ft.

In March 2005, the Corps revised operation philosophy by targeting lower elevations in the winter and early spring. The lower target zone during the flood season reduced the impact of rainfall events on pool elevation. The Corps also took a more aggressive stance on lowering the lake level during and following an event. This included events that did not put the lake elevation into the flood control pool. This revised operating zone was devised to lower piezometric pressure without significantly impacting the flood damage reduction, hydropower, navigation, fish and wildlife, water supply, and water quality operating objectives of the Cumberland Basin reservoir system that are so dependent on operations at Wolf Creek. In the past, when the lake level spiked up, it would have been allowed to return to the PMB in a gradual manner, allowing for the most efficient use of the water for power production and other water management objectives.

Figures 2 and 3 illustrate the above operating philosophies. Figure 2 presents data for the period 1984-2004 along with the PMB and the revised operating zone. It is apparent that the overriding objective during this period was to fill the pool to elevation 723 ft by the end of May. If a rainfall event resulted in an early fill then the flood control pool (>723 ft) was quickly evacuated followed by a controlled return to a target elevation of 723 ft. Figure 3 presents data for 2005 and 2006. The peak headwater elevation in 2005 (after the new criteria were established) was 726.3 ft. The highest headwater elevation in 2006 was 724.0.

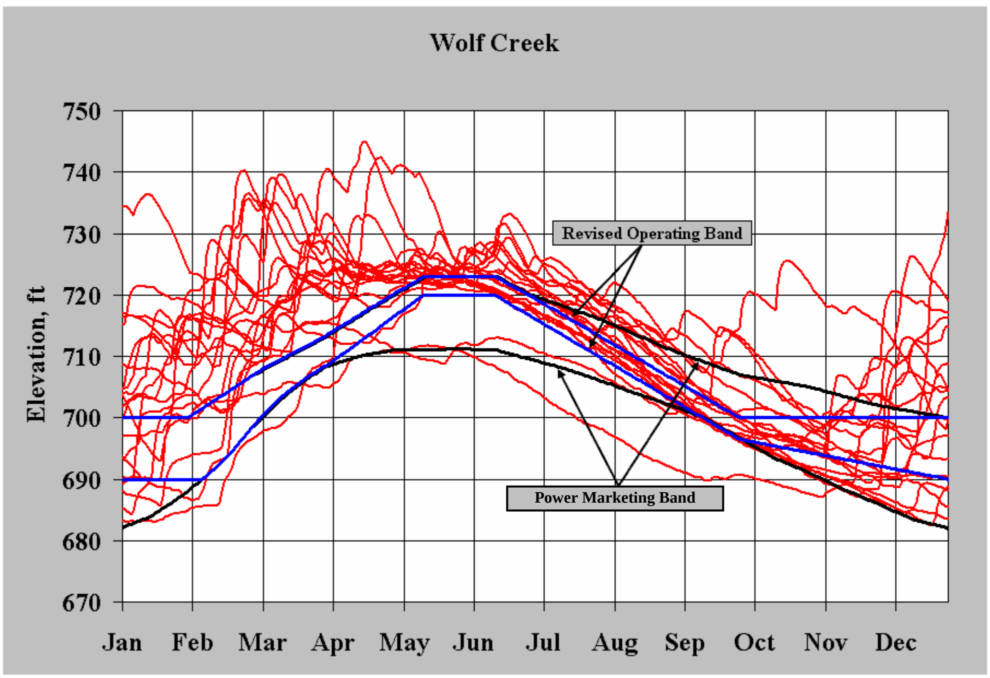


Figure 2 – Lake Cumberland Pool Elevations prior to 2005.

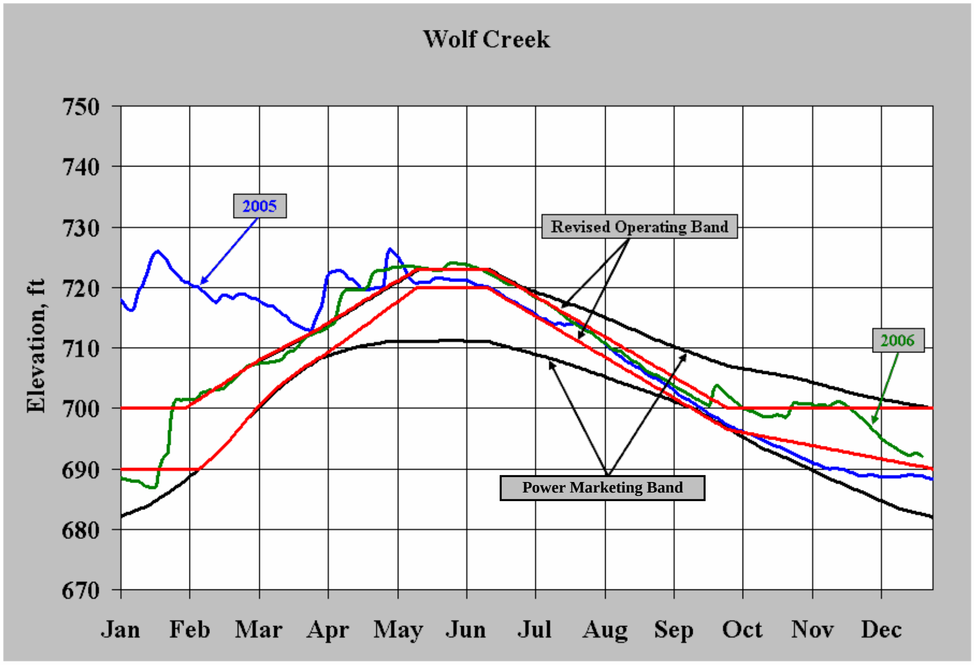


Figure 3 – Lake Cumberland Pool Elevations for 2005 and 2006.

1.2.2. Risk Reduction Operation. The current risk reduction measure for Wolf Creek Dam is to target a year-round elevation of 680 ft. This operation will reduce the volume of water stored in the hydropower pool by about 1,885,000 acre-feet (88.0%), and will severely impact both project specific and system operations. A graph below shows the current 2007 headwater elevations at Wolf Creek (Figure 4).

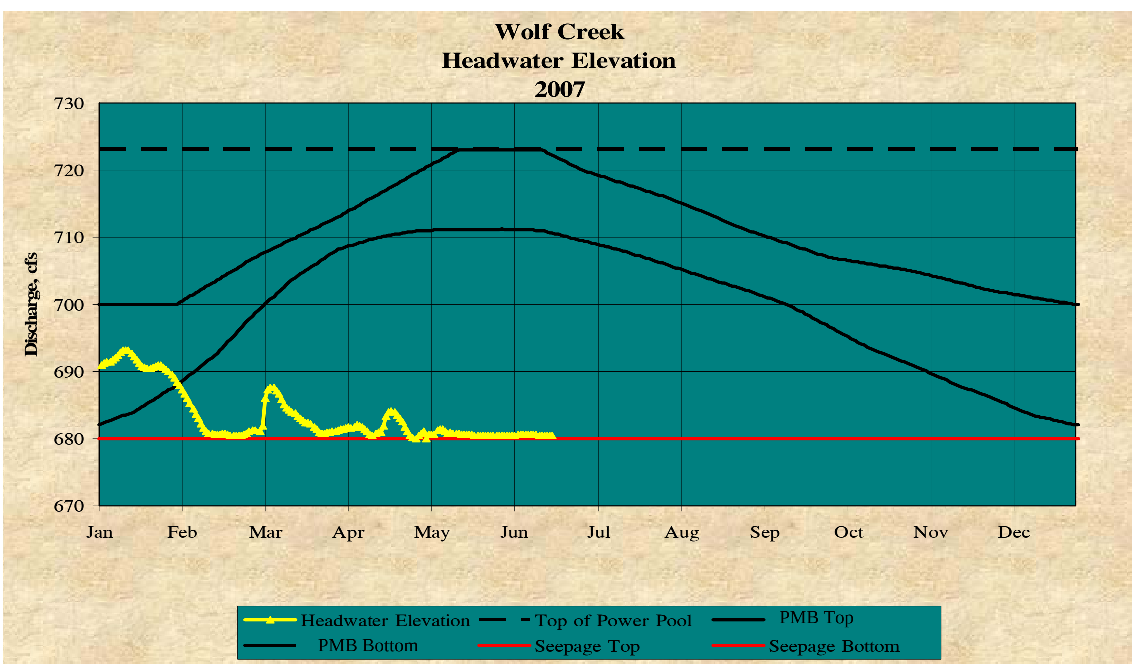


Figure 4 – Lake Cumberland Pool Elevations for 2007.

1.3. Purpose and Need for Action. Wolf Creek Dam was built on karst geology (highly erodable limestone) using accepted engineering practices of the day. Since the 1960s, seepage through the dam's foundation has been a concern. Repairs have been implemented at various times including grout injection into the foundation and the installation of a diaphragm wall through about two thirds of the earthen embankment. Those repairs are credited with saving the dam, however, some seepage remained. Over the last three decades the problems have increased and the dam is now classed as being in an active failure mode.

Due to the risk imposed on downstream populations by the dams' instability, on January 19, 2007, the Corps deemed it necessary to take emergency action and lower the target pool elevation at Lake Cumberland to 680 ft to ease the stress on the dam's foundation until repairs can be made. This action is being taken to reduce risk to the public's safety and welfare. The Corps believed that the need for action regarding the Wolf Creek Dam was so urgent and compelling that there was no time to follow the usual NEPA procedures before the Corps made decisions and began to implement them. The Corps, therefore, invoked its authority under 33 CFR 230.8 "Emergency Actions", and declared an emergency, made decisions, and took necessary actions accordingly. The Corps consulted the President's Council on Environmental Quality (CEQ) regarding alternative arrangements under NEPA pursuant to 40 CFR 1506.11.

The Corps recognizes that lowering the lake has many significant impacts to hydropower production, water quality, fish and wildlife, recreation, municipal water supplies, and economics. The Corps also notes that due to the uncertainty and dynamics of the situation it may be necessary to lower the lake even further at some future date.

1.4. Public Review Process.

In preparing this EIS, a Notice of Intent was published in the Federal Register on February 2, 2007 and a Scoping Letter was sent to all known interested individuals on March 23, 2007. A total of 20 comments were received in response to these notices. These comments are included in Appendix C.

Copies of the Draft EIS and a Notice of Availability (NOA) were mailed out October 5, 2007. Also, a NOA was published in the Federal Register on October 12, 2007. Eleven comments were received from this review and are included in Appendix D.

1.5. Consultation and Required Permits.

- National Historic Preservation Act – Section 106 review. Consultation with the State Historic Preservation Officer is currently underway. The degree of effect on cultural resources will depend on the lake levels that are finally decided upon. Drawdowns within the normal range of operations will require no action. Radical drawdowns will require additional consultation with the State Historic Preservation Officer and the implementation of historic property surveys.

- Section 7 – Endangered Species Act. Because the current conditions of targeting a pool elevation of 680 ft at Lake Cumberland and the final determination of the action both may have a direct impact on federally proposed or listed species; and because of their expertise on the subject, the USFWS has agreed to be a cooperating agency. Informal Consultation has been initiated with the USFWS to determine what, if any, impact reduced lake levels may have on threatened or endangered species. A Biological Assessment has been completed (Appendix A) and it lists seven species as having a "may affect, but not likely to adversely affect" determination.
- Fish and Wildlife Coordination Act Report. A Fish and Wildlife Final Coordination Act Report has been requested.
- Executive Order 11988 - Floodplain Management. Alternative 1 – No Action, has the potential of increasing the risk of a "base flood", but only in the event of a dam failure. All other alternatives increasingly reduce the risk of a "base flood" as the top pool elevation is lowered under each following alternatives.
- The TVA has agreed to be a cooperating agency; however, a TVA 26a permit is not required for this action. TVA was requested to be a cooperating agency, because of the potential impacts to their operations and of their expertise in power production, navigation, the Natural Heritage Program, and other areas.

2.0 Alternatives Including Proposed Action

2.1. Actions Taken to Minimize Risk. Several steps have already been taken to minimize the risk to downstream populations. These are described below.

2.1.1. Aggressive Adherence to Established Guide Curves. Prior to 2005, winter rainfall was captured and released slowly to maximize hydropower production. Beginning in 2005, the Corps began rigidly adhering to the established guide curve. Hydropower was no longer reserved only for peaking hours. Instead, the pools were aggressively drawn down to match the operational guide curves. This reduced the high peaks of pressure on the foundation. Over the last two years there has been a documented reduction in the number and size of wet spots at the toe of Wolf Creek Dam. This action is within the scope of the EIS for operation of Wolf Creek Dam .

2.1.2. Increased Monitoring. Several types of inspections as described below are conducted at the dams on a routine basis.

- Periodic inspections are held every five years. These are performed by a multidisciplinary team who conducts a very detailed analysis of all of the data collected over the previous five years including surveying the structure, physical inspections of all aspects of the structure, and a comparison of any changes since the previous inspection.
- Intermediate inspections are held annually. Although not quite as detailed as the periodic inspections, they do review all of the recorded monitoring data from the previous year, and include a physical inspection of the embankment, tunnels, and galleries.

- Quarterly inspections are conducted by dam personnel. These were changed to monthly inspections in June 2005.
- Weekly inspections conducted by dam personnel were increased to daily inspections in November 2006.
- 24 hour surveillance of the dam, through cameras in the control room of the power plant and by foot patrols of the face and toe of the dam, was initiated in December 2006.

The above listed measures do not trigger the requirement for NEPA documentation.

2.1.3. Emergency Action Planning. A key factor in risk reduction is the coordination with local and state emergency management staff. Their inclusion in this work is vital to successful emergency preparedness planning. The planning includes keeping the Emergency Action Plans (EAP) up to date and providing copies of this data to appropriate personnel both internally and externally. Each Corps employee listed in the EAP has been provided with two copies of the call notification structure to have with them at all times. Updated inundation mapping has been provided to the local and state emergency managers and any first responding agencies in event of a failure. The inundation mapping will be based on updated hydrology and hydraulic data, and provide failure scenario data. To ensure all entities are prepared to respond during a failure, a functional emergency exercise was conducted bringing all responders together. The exercise was designed to test the responder's actions to a failure scenario. In addition, internal Corps' call notification exercises will be conducted to improve the response to changes at the dam. This measure does not trigger the requirement for NEPA documentation.

2.1.4. Dam Safety Training of Project Personnel. Typically dam safety training of all project personnel occurs every five years during the periodic inspection. Training of personnel has increased and is frequently mentioned at the monthly safety meetings. This measure does not trigger the requirement for NEPA documentation.

2.1.5.   Public Meetings. Approximately 32 public meetings have been held to make the local populations and emergency management agencies aware of the potential problem and to help plan for the possibility of a dam failure. These meetings were held at Smithville, Cookeville, Carthage, Hendersonville, Gallatin, Celina, Gainesboro, Hartsville, Mount Juliet, and Nashville, Tennessee and in Somerset, Russell Springs, Burkesville, and Tompkinsville, Kentucky. Also, many one-on-one meetings were held with elected officials and emergency managers. This measure does not trigger the requirement for NEPA documentation.

2.1.6. Stockpiling Emergency Materials. In order to quickly react to a significant change in conditions at Wolf Creek, the project should stockpile, at a minimum, sand, 57 stone, and filter fabric. In addition, sandbags and equipment to fill sandbags should be stored at the project. It is critical to have materials on-site to react quickly to a change in condition of the dam. Having these materials on hand could potentially prevent the total loss of the structure. Since these emergency materials would be stored at previously developed areas of the project, this measure would be categorically excluded from NEPA documentation under ER 200-2-2, Paragraph 9.a.

2.1.7. Inundation Mapping. Inundation mapping for a dam failure were developed based upon the conditions at Wolf Creek Dam and the potential failure scenarios described in Section 3. The result of this mapping was a set of three failure scenarios; red, blue, and green. The three scenarios were derived from numerous hydraulic modeling computations. The inundation scenarios reflect a low, medium, and high upstream pool condition at Lake Cumberland. Hard copies and electronic copies of these maps were provided to the County, State, and Federal officials responsible for planning and responding to a potential dam failure. This mapping was provided so officials are effectively prepared to react to a failure condition. The Corps also made the decision to publish the mapping electronically to the public. This capability was added to the Nashville District, Corps website per that guidance. This measure does not trigger the requirement for NEPA documentation.

2.1.8. Coordination with other Agencies. Nashville District Corps meets with Local, State and Federal agencies to provide updated data, coordinate emergency planning, and test the responsiveness of plans implemented. The National Weather Services (NWS) has been identified as the first contact in the failure response scenario in the Wolf Creek EAP. As the first contact, a pre-scripted dam failure warning message has been derived to quickly broadcast over the emergency alert system the NWS utilizes. As part of this system the State of Kentucky Department of Homeland Security (KDOHS) has provided NOAA weather radios to those homes that were identified as inundated on the Corps dam failure inundation maps. In addition, the KDOHS has placed evacuation route signage along evacuation corridors in the affected area. The Kentucky Emergency Management Agency received and approved evacuation plans from each of the 4 counties affected. These plans were set up from the Corps inundation mapping, flood hydrographs, and travel times of the flood mapping. This measure does not trigger the requirement for NEPA documentation.

2.1.9. Communication Plan. A plan to establish communication goals and objectives with the goal of maintaining an open communication with our target audience to include the public, private industry, local-state-federal government, and congressional representatives has been developed. This plan includes the use of public notices and press releases to broadcast information regarding Wolf Creek Dam. Telephone calls, email lists, and public meetings are all methods to be utilized as part of this communication plan. The Corps, Nashville District, website will be utilized as a source of communication as well. The plan will be continually updated and evaluated to account for comments from stakeholders and the public and to incorporate lessons learned. This measure does not trigger the requirement for NEPA documentation.

2.1.10. Emergency Grouting Program. Nashville District has contracted with Advanced Construction Techniques, LTD (ACT) as a foundation grouting specialist to install new grout curtains. This contract was awarded in September 2006 and the grouting in the critical wrap around section began in January 2007. This grouting is expected to have an immediate effect on the distress indicators in the project. ACT is teaming with sub-contractors from Gannett Fleming and Intelli-grout that constructed the newly installed cut-off wall at Mississinewa Dam in Indiana. The grouting contract was expedited to begin this work ahead of previous schedules. This measure is evaluated by an Environmental Assessment (EA) and signed Finding of No Significant Impact dated January 2005. The EA is titled Environmental Assessment: Wolf Creek Dam Seepage Reduction Study.

2.2. Description of Alternatives. Due to the emergency nature of the dam's integrity, Alternative 2, Maintain Lake Cumberland pool height at 680 ft and Alternative 5, Manage the Cumberland River system in accordance with an Interim Operating Plan, have already been chosen and are being carried out. However, because of the uncertainty and dynamics of the situation or if new information is obtained, it may be necessary to take a different approach at some future date. Therefore, additional alternatives are being evaluated. These alternatives and the actions described in section 2.1 are included in a document called the Wolf Creek Dam Interim Risk Reduction Measure Plan.

The Corps has developed a decision making process to decide at what pool level Lake Cumberland would be held. This decision making process will be used at different points in time for the duration of the construction project regardless of alternative chosen. Examples of times at which this process would take place are: completion of the upstream grout line (estimated Early 2008), completion of the downstream grout line (estimated September 2008), completion of the cut-off wall in Critical Area 1 (estimated September 2009), etc. The process will be based on the completion of these structural measures and validated by performance indicators and continued overall stability and improvement in Wolf Creek Dam. The performance indicators are: the continued stable, downward trend of Piezometer readings, continued stable trend of wet spots, no anomalies in monitored settlement, and no anomalies based on visual inspections. This information will be used by a vertical team and a Corps advisory panel to make recommendations on incremental pool level changes of no more than 10 feet at a time.

2.2.1. Alternative 1, No Action. This alternative is defined as maintaining the established guide curves (reference figures 2 and 3). Lake Cumberland would be allowed to fill to approximately elevation 723 ft by May and then gradually drawn down to approximately elevation 690 ft. by October. The dam would continue to be operated to maximize a balance of all authorized project purposes.

2.2.2. Alternative 2, Maintain Lake Cumberland pool height at 680 ft. This alternative would see Wolf Creek Dam, Lake Cumberland, operated with a target elevation of 680 ft. The management goal would be to make all attempts to keep the pool elevation at a "flat line" 680 ft. Pool elevation may jump to higher elevations when rain events occur; however, it would be drawn down aggressively back to 680 ft. Elevation 680 ft is the lowest point, in which the lake could be lowered, in which additional risks to human health and safety were not imposed by risking the operation of municipal water intakes.

2.2.3. Alternative 3, Maintain Lake Cumberland pool height at 650 ft. This alternative would be similar to Alternative 2, except the target pool elevation would be managed for approximately 650 ft.

2.2.4. Alternative 4, Maintain Lake Cumberland with a partial fill guide curve between 685 and 700 ft. This alternative would see Wolf Creek Dam, Lake Cumberland, operated with an adjustable top of pool anywhere in between 685 and 700 ft. Water managers would have the freedom to adjust the pool height based on weather, navigation requirements, water quality requirements, etc. This band would act as a target band and should not be considered fixed. One management scenario could be allowing Lake Cumberland to fill to elevation 700 ft by May and then drawn back down to elevation 685 ft by sometime around October.

2.2.5. Alternative 5, Manage the Cumberland River system in accordance with an Interim Operating Plan. The Cumberland River has been developed into a system of ten multipurpose water resources projects. The demands of managing this "system" of differing water resources are at times conflicting and water control managers must have some degree of operational flexibility. The Corps has developed a draft Interim Operating Plan (see Appendix E), that outlines how project and system operations may be impacted and how this system will be managed during this period of pool restrictions.

From early 1985 through most of 1988, the Cumberland Basin experienced a severe drought. The Corps applied lessons learned from that time to develop an operating policy for drought conditions. The final product of that evaluation was the Cumberland River Basin Drought Contingency Plan, published in November 1994. Recommendations from the Drought Contingency Plan are coupled with further recommendations made in the Interim Operating Plan to form a basis of how the Cumberland River System could be operated under this alternative. The established system regulation priorities, in order of significance, are as follows:

1. Water Supply
2. Water Quality
3. Navigation
4. Hydropower
5. Recreation

Under this Interim Operating Plan, it is recognized that day to day reservoir system operations are highly dependent on meteorological conditions, specifically the amount and distribution of rainfall and observed air temperature. System conditions would be evaluated on a daily basis and a forecast would be developed consistent with the overall system operating objectives. The existing precipitation, stream flow, and water quality remote monitoring network is designed for routine system operations. It would be supplemented as necessary to collect the information needed to develop the best possible forecasts. A number of Cumberland River Basin control points have been identified that would serve as overall guides for system operations. The system would be managed for these control points through application of the system priorities contained within the drought contingency plan (noted above). It is anticipated that these control points would be dynamic in nature, with one or more factors influencing system operations at any given time.

2.2.6. Alternative 6. Maintain Lake Cumberland pool height at 610 ft. This alternative would be similar to Alternative 2 and 3, except the target pool elevation would be managed for 610 ft. This alternative will not be fully evaluated for following reasons.

Elevation 610 ft coincides with the invert elevation of the hydropower intakes. Due to the large drainage area of the project (5,789 mi2) and the comparatively small discharge capability afforded by the six hydropower units and six sluice gates (invert 562 ft), it is not possible to follow a flat-line drawdown with any degree of certainty. Also, the hydropower units are not designed to operate below 673 ft. Lake Cumberland will rise faster at the lower elevation than what is observed during normal operations due to the smaller volume per unit of depth. Based on results of a ResSim analysis by the Corps, the pool would be above elevation 610 ft for 90% of the time.

Another condition that might arise from targeting 610 ft is destabilizing the soil in the foundation by frequent wetting and drying cycles. In the critical zone at the soil rock interface 60% of the embankment's foundation is at or above elevation 610 ft and will be subjected to numerous cycles of wetting and drying each year. This condition is a well documented cause of sinkhole collapse in karst regions. Given the known foundation conditions under Wolf Creek Dam, there is a moderate to high probability that this will occur if targeting 610 ft for the top of pool. Accelerated piping during rapid pool rises is also a possibility.

2.2.7. Alternative 7. Construct a new roller-compacted concrete dam downstream of the existing dam. A roller-compacted concrete dam (RCCD) is constructed from a "dry" mix of concrete that can be placed in layers and compacted by heavy equipment. Under this alternative, an RCCD would be constructed to replace the existing earthen embankment section of Wolf Creek Dam. Lake Cumberland would be lowered to approximately 650 ft during most of the excavation and construction of the RCCD. During the tie in of the new RCCD section with the existing concrete monoliths, the lake would have to be lowered to at least elevation 610 ft.

2.3. Summary of Indirect and Cumulative Impacts. Cumulative impacts are defined as "the impact on the environment which results from the incremental impact of the (proposed) action when added to other past, present, and reasonably foreseeable future actions regardless of what agency or person undertakes such other actions (40 CFR 1508.7)". Based on the public and agency scoping and review performed for the previous NEPA documents conducted for this project, the following resources were identified as target resources within the assessment goals: socioeconomics, water quantity, water quality, aquatic resources, threatened and endangered species, recreation/tourism, river navigation, and cultural and historic resources.

The ten multipurpose projects in the Cumberland River Basin are operated as a unified system. Water releases are coordinated among the projects to minimize flooding throughout the Cumberland River system. A reduced pool would directly affect other project purposes at Lake Cumberland and indirectly the system purposes of hydro and thermal power production, water quality, water supply, aquatic resources, endangered species, recreation, and navigation. The severity of impacts is related to the climate during the year. Center Hill Dam is suffering through similar problems to those that Wolf Creek is experiencing and has required lowering the storage of Center Hill Lake. Dale Hollow, Wolf Creek, and Center Hill Dams provide most of the water flow in the Cumberland River. Great demand would be placed on Dale Hollow Lake to store additional water early in the year and to release it throughout the dry periods to supplement the flow of the Cumberland River. Storage restrictions at Wolf Creek and Center Hill Dams would result in reduced water quantity in the Cumberland River. The impacts of reduced water storage would be felt to the confluence of the Cumberland and Ohio Rivers. Without water storage at Wolf Creek and Center Hill Dams, the entire Cumberland River System has the potential to stagnate. The resultant low flows in the Cumberland River could affect electrical production at both hydro and fossil fuel power plants, water quality, aquatic resources, threatened and endangered species, municipal water supply, economics, recreation, and navigation.

<u>Electrical Power Production.</u> TVA's Gallatin and Cumberland City steam plants rely on the water supply provided by the Cumberland River system for cooling water flow. Also, Eastern Kentucky Power Corporation's Cooper Power Plant relies on water supply from Lake Cumberland. The lack of storage in Lake Cumberland would mean that there is less water available for release into the Cumberland River. If there is insufficient flow in the Cumberland River, then water temperatures may be too high to cool thermal plants. Also, if Lake Cumberland drops to low, Cooper Power Plant may not be able to withdrawal water for cooling. In addition, lack of water storage would mean that there is less water available for the hydropower plants to provide peaking power when it is most needed. Loss of hydro and thermal power production could result in brownouts or even blackouts if other sources of supply are insufficient.

<u>Water Supply</u>. The water supply intakes on Lake Cumberland are located within or near to the bottom of the power pool (673 ft) and are likely to be affected. If the lake experiences algal booms there could be taste and odor problems which would require increased water treatment costs. Other intakes are located downstream of the dam. Under drought conditions, low flows could result in their forced closure. The Corps notified and recommended water supply users to make adjustments to their intakes to withdrawal water as low as elevation 650 ft. Currently, many are in the process of altering their systems but non have been completed.

<u>Socioeconomics</u>. Wolf Creek Dam, Lake Cumberland Reservoir has contributed to the regions socioeconomics by providing inexpensive hydropower, cooling water for thermal power plants, reliable water supply, recreation, flood damage reduction, and to a limited extent it has aided in navigation and inexpensive transportation of goods. The lower Lake Cumberland pool is maintained, the less water is stored to meet these demands.

Each of these uses would be negatively affected to a greater or lesser degree depending on the lake storage level attained and the amount of rainfall.

Water Quality. Good water quality is a key to Lake Cumberland supporting all its designated uses. Lower lake levels and less storage capacity could result in poorer water quality not just immediately downstream of Wolf Creek Dam, but throughout the downstream length of the Cumberland River to its confluence with the Ohio River. Municipal and commercial water suppliers would face greater treatment costs and up to eight Federal threatened or endangered species could be negatively affected. Discharges from Wolf Creek Dam could violate state water quality standards. There are water quality concerns within Lake Cumberland as well. High nutrient levels from runoff into the lake from some agricultural areas and waste water plants are cause for concern at times. As the lake level drops, nutrients could concentrate, resulting in algal blooms. Algal die-offs deplete dissolved oxygen (DO), resulting in the potential for fish kills.

Aquatic Resources. As noted above, water quality becomes poorer if there is insufficient stored water in the Lake Cumberland reservoir. Poor water quality directly affects aquatic organisms. Low DO and higher temperatures would add stress to fish and mussels. Poor conditions could also trigger algal and bacterial blooms which would further distress the ecosystem. Fish kills could be anticipated. Major die-offs would negatively affect recreation which, in turn, would affect the economy. The long term sustainability of listed threatened or endangered species would also be negatively affected.

Flood Damage Reduction. Allowing the dam to be lost by failing to effect repairs would be catastrophic for downstream populations. An unintended side effect of maintaining a reduced pool to alleviate pressure on the dam's foundation is that it would actually create additional flood storage capacity. However, since captured flood waters would be evacuated as quickly as possible without increasing downstream flooding, this increased storage capacity could be compromised.

Recreation. During the expected seven years of dam repairs, recreation on Lake Cumberland would be negatively impacted. Depending on the elevation selected, all of the boat ramps could become unusable, all of the marinas could be closed, and many, if not all, of the private docks could be inaccessible. As fishing conditions declined, so too would recreation. Access to the lake would be severely restricted or lost, resulting in economic hardship for the local economy. Though the effects would be temporary, it could take years to recoup the financial losses. Safety concerns would also increase as navigation hazards (submerged logs, rocks, shallow gravel bars) develop in Lake Cumberland.

Navigation. Navigation is not a project purpose at Wolf Creek Dam. However, under normal operations, tailwater releases are part of the flow in the Cumberland River used by navigation. During repairs, tailwater flow would be restricted, providing little water to the system. A nine-foot commercial navigation channel on the Cumberland River upstream of Barkley Dam is generally supported by the maintenance of full, flat pools at the four main-stem dams. If the customary releases from Wolf Creek and Center Hill are not available, the Corps' ability to maintain the nine-foot channel may be compromised. This would, in turn, affect transportation costs and the economy. Also, flows in the tailwater below Barkley Dam would not be supplemented by the Tennessee River.

2.4. Unavoidable Adverse Effects. The decision to lower the Lake Cumberland pool elevation detracts from authorized project purposes and increases negative impacts on several important resources. The goal of this EIS is to document and disclose the impacts of alternatives considered, and to make informed decisions regarding future Lake Cumberland pool level targets and possible repairs. Lowering and maintaining a reduced pool would have negative effects on hydropower, water supply, recreation, water quality, fish and wildlife management, threatened and endangered species, and navigation. Under the worst case scenario hydropower production would be foregone, thermal power plants would likely be de-rated or shut down due to lack of cooling water, recreation would decline as boat ramps and marinas were closed, navigation would be reduced, water quality would decrease to the point of violating state water quality standards, Federal threatened and endangered species would be stressed and some could be lost, algal blooms and fish kills would increase, water treatment costs would increase, and the economy would be impacted. The actual severity of the impacts would depend on a number of factors including the chosen pool level operation to be maintained, weather including rainfall and temperatures, and conditions at other lakes within the Cumberland River Basin. Theses negative short-term affects are unavoidable, but considered prudent when weighed against the risk of dam failure.

2.5. Mitigation Measures. When designing a project, negative environmental impacts are to be avoided wherever and whenever possible. Where negative impacts cannot be avoided, they must be minimized. Compensation may be made where practicable for impacts that can be neither avoided nor minimized.

It may be possible to avoid or minimize impacts by installing structural features on dams, or changing system operations. These following discretionary measures have been developed for consideration by the U.S. Army Corps of Engineers as actions that could be undertaken by the Nashville District as reasonable and prudent measures. Some of these measures have already been implemented. Others are still under consideration and may be implemented when possible.

2.5.1. Installation of an Orifice Gate. To provide minimum oxygenated water flow below Wolf Creek Dam an orifice gate can be installed over a sluice gate. Installation of one orifice gate at Wolf Creek Dam was completed on 24 October 2007. Stream flow measurements made shortly after the gate was installed indicated a discharge of approximately 280 cubic feet per second when the lake is at about elevation 679 feet. A second orifice gate is planned. Once both gates are in place a discharge of approximately 500 CFS should be achieved.

2.5.2. Blending Turbine and Sluice Gate Discharges. The average discharge of water from a turbine at Wolf Creek is between 3,500 and 4,000 cfs depending on the lake level.

During the warmer months of the year, i.e., roughly May through October, the water stratifies and virtually all DO in the deeper portions of the lake is consumed by ongoing chemical and biological processes. Consequently, water discharged through the turbines is very low in DO and the tailwater ecology suffers. In recent years the Corps has been experimenting with releases through the sluice gates to compensate for this problem. Water discharged through the sluice gates can have as much as 10 mg/l of DO. Each of the six sluice gates can discharge about 1,500 cfs. Thus, when generation is required during the warmer months a sluice gate can be opened and as the waters from the turbines and the sluices blend, adequate DO is achieved within a short distance downstream from the dam.

2.5.3. Supplemental Flows from Other Tributary Lakes. It may be possible to store some excess water in Dale Hollow and/or J. Percy Priest Lakes early in the year and slowly release this water over the summer to mitigate for the reduced flows from Center Hill. Likewise, additional water could be stored at Laurel River Lake above Wolf Creek Dam to help with recreation and water supply within Lake Cumberland. This course of action would be dependent on several factors including the amount of rainfall and several operational factors. This was done to a limited extent in 2007 when Dale Hollow was filled to about 653 ft, or approximately two feet above the top of the power pool. This action would have to be planned and approved in advance to make any significant difference. Other changes to the Cumberland River Reservoir System to maintain water quality are described in the Interim Operating Plan (See Appendix E). This action was begun in 2007. In 2007, Dale Hollow Lake was filled to a higher level than in past years. In late summer and fall 2007, water was obtained from Laurel River Lake in order to partially replace water being withdrawn from Lake Cumberland. At J. Percy Priest, option exists in the future to supplement flows in the Cumberland River by spillway releases rather than the intermittent generation of hydropower

2.5.4. Spill vs. Generation. As noted above, the preferred method for regulating lake levels is by hydropower generation. However, during the summer months when water quality in the mainstem lakes typically decreases, the Corps has occasionally resorted to spilling water through the mainstem tainter gates rather than by generating because this increases the DO in the tailwater where most of the species of concern are likely to be found. The disadvantage of this, of course, is the power lost by foregoing hydropower generation. Wolf Creek Dam can only discharge water through its flood gates when the pool is in flood stage, i.e., above 723 ft. This form of mitigation would not, therefore, apply to Wolf Creek Dam or any of the upstream tributary lakes. But it can apply to the lock and dam projects on the mainstem of the Cumberland River.

2.5.5. Aquatic Habitat Improvement. Funding and approval has been requested to construct aquatic habitat structure within Lake Cumberland while lake levels are lowered. Should funding be approved and received, consultation with Kentucky Department of Fish and Wildlife Resources to determine designs and locations of habitat structure will be initiated.

2.5.6. Recreation Improvement. Where practicable, boat ramps have or are being extended by the Corps, Kentucky, and individual counties, to allow access to the lake. So far, 17 ramps have been extended by at least one lane. Marinas would be allowed to re-configure and/or relocate to more suitable areas, however, additional NEPA reviews/documentation are required for this action. Two marinas have requested to relocate. Due to lower lake levels on Lake Cumberland, certain lakeshore camping sites are no longer accessible by water, nor do they have direct access to water. Therefore, camping fees for waterfront sites were lowered. Improvements are being made to Kendall Campground below Wolf Creek Dam such as new paving additional camping sites, new shower house, etc. Recreation areas are remaining open to allow a longer recreation season. A waiver of rent has been granted for marina concessionaires.

2.5.7. Supplemental Tailwater Intake for Wolf Creek National Fish Hatchery. Wolf Creek National Fish Hatchery normally draws its water from the upstream side of Wolf Creek Dam. Because of the drawdown, the temperature of the hatchery's water supply could increase to detrimental levels. In anticipation of this, the Corps of Engineers installed a supplemental water supply to the hatchery that mixes cold water drawn from the downstream side of the dam with the water drawn from the upstream side of the dam. The supplemental water supply system draws its water from the tailrace area of the dam and pumps it through a piping system that distributes and mixes the water with the existing water supply system. The supplemental system consists of two 5,000 gallon per minute (gpm) pumps located in the tailrace discharge area of the dam, a 24 inch pipeline to delivery the water to the hatchery, and a manifold system located at the hatchery to distribute the water. The maximum output of the supplemental water system is 10,000 gpm. The system is temporary and is scheduled to operate from July to December each year until the reservoir is returned to its normal operating level. This system went into operation on August 7, 2007. Recently an alarm system was installed to alert Corps and USFWS personnel in the event of a pump failure. Wolf Creek Dam's control room is staffed at all times. Should there be a pump failure; the second pump would be started manually.

2.5.8. Mitigation for impacts to Historic Properties. The Nashville District has proposed that adverse effects to historic properties be addressed by stipulations within a Programmatic Agreement (PA) amongst the Corps of Engineers, the Advisory Council on Historic Preservation, and the Kentucky State Historic Preservation Officer; relevant Native American tribes would be invited to concur in the agreement. The agreement would stipulate requirements for additional survey, limited archeological testing to determine National Register eligibility, and data recovery, should that be determined necessary. Consultation is on-going.

2.5.9. Public Communication. Interested parties will be kept informed of current information regarding all aspects of the Wolf Creek seepage rehabilitation construction project. Current information is kept up to date on the Corps, Nashville District website. The web address for that site is: http://www.lrn.usace.army.mil/WolfCreek/. Information will be maintained at this address for the duration of the construction project.

2.6. Comparison of Alternative Pool Elevations and Resource Impacts. Impacts are most notable during the summer months when demands on project uses are the greatest. Based on historical operations, the range of conditions that may occur to project uses as the lake is operated under each alternative can be predicted. It is important to note that Alternative 1 represents the normal operating band under normal conditions. Only in the event of a dam failure, would the impact to important resources would be severe under Alternative 1. Studies have shown that maintaining a high summer pool increases the risk of dam failure, until repairs are complete enough to support the hydrostatic pressure without loss of dam integrity. It is expected that in the event of a dam failure, the lower the pool elevation the lower the flood damage downstream. Table 1 provides an indication of the impact to important resources under each interim pool elevation alternative. The dash line indicates no significant impact to that resource.

2.6.1. No Action. The No Action alternative would see a continuation of the status quo, i.e., there would be no change to the operating guide curve that has been in effect for the last several years. This guide curve maximizes a balance of all authorized project purposes.

2.6.2 Alternative 2, Maintain Lake Cumberland pool height at 680 ft. and Alternative 5, Manage the Cumberland River system in accordance with an Interim Operating Plan. As noted above, these alternatives have already been selected and implemented. The emergency drawdown has had moderate to severe impacts on all project purposes except flood control. It has also severely impacted the regional economy. This alternative has been undertaken despite the anticipated drawbacks because of the possible instability of the dam's foundations and the consequences on downstream populations if the dam should fail. The intended purpose of the Interim Operating Plan is to identify potential water management conflicts and outline how the Cumberland River reservoir system will be operated to best address water management issues. It provides Corps, Nashville District Water Management with an approved operational guide from which day to day water control decisions can be made.

2.6.3 Environmentally Preferred Plan. The environmentally preferred plan would be to continue to operate within the existing guide curve; however, the consequences of a dam failure are so enormous that they outweigh the anticipated negative impacts to the environment. It should be noted that although the possibility of dam failure is considered small, the consequences to the environment would be far more severe than those incurred by a drawdown of Lake Cumberland to 680 ft. If indicators of dam stability permit a raising of lake levels, Alternative 4, Maintain Lake Cumberland with a partial fill guide curve between 685 and 700 ft, would have less impact and be more desirable from a water management and resource perspective. Once repairs to Wolf Creek are complete operations would return to normal.

Table 1
Comparison of Impacts

Environmental and Economic Impacts	Alternative 1 No Action	Alternative 2 Target EL 680 ft	Alternative 3 Target EL 650 ft	Alternative 4 Partial Fill Guide Curve EL 685/700	Alternative 5 Interim Operating Plan
Safety	**Severe**	**Minor**	**Minor**	**Minor**	**Minor**
T & E Species	*	**No Adverse**	**No Adverse**	**No Adverse**	**No Adverse**
Aquatic Resources	*	**Severe**	**Severe**	**Moderate/Severe**	**Moderate/Severe**
Coldwater Fishery	*	**Severe**	**Severe**	**Moderate/Severe**	**Moderate/ Severe**
Water Quality	*	**Severe**	**Severe**	**Moderate/Severe**	**Moderate/Severe**
Wildlife Resources	*	**Minor**	**Minor**	**Minor**	**Minor**
Wetland Impacts	*	**Negligible**	**Negligible**	**Negligible**	**Negligible**
Water Supply	*	**Minor**	**Severe**	**Minor**	**Minor - Severe**
Historic Properties	*	**Severe**	**Severe**	**Minor - Severe**	**Minor - Severe**
Low Water Flow	*	**Moderate**	**Severe**	**Minor**	**Minor - Severe**
Increased Tailwater Heights	*	-	**Severe**	**Minor**	**Minor - Severe**
Shoreline Erosion	*	**Moderate**	**Severe**	**Moderate**	**Moderate/ Severe**
Environmental Justice	*	-	-	-	-
Recreation	*	**Severe**	**Severe**	**Severe**	**Moderate/ Severe**
Aesthetics	*	**Minor**	**Moderate**	**Minor**	**Minor**
Air Quality	*	**Minor**	**Minor**	**Minor**	**Minor**
Noise	*	-	-	-	-
HTRW	*	-	-	-	-
Flood Control	*	**Minor**	**Minor**	**Minor**	**Minor**
Hydropower	*	**Severe**	**Severe**	**Severe**	**Severe**
Fossil Fuel Burning Power	*	**Minor - Severe**	**Severe**	**Minor/ Moderate**	**Minor - Severe**
O & M Costs	*	-	-	-	-
Economics	*	**Severe**	**Severe**	**Severe**	**Severe**
Traffic	*	-	-	-	-
Navigation	*	**Minor - Severe**	**Minor - Severe**	**Minor/ Moderate**	**Minor - Severe**
Public Facilities	*	**Moderate/Severe**	**Severe**	**Minor/ Moderate**	**Minor - Severe**
Public Services	*	**Moderate/Severe**	**Severe**	**Minor/ Moderate**	**Minor - Severe**
Employment	*	**Moderate/Severe**	**Severe**	**Minor/ Moderate**	**Minor - Severe**
Tax Values	*	**Moderate/Severe**	**Severe**	**Minor/ Moderate**	**Minor - Severe**
Property Values	*	**Moderate/Severe**	**Severe**	**Minor/ Moderate**	**Minor - Severe**
Community Cohesion	*	**Moderate/Severe**	**Severe**	**Minor/ Moderate**	**Minor - Severe**
Displace People	*	**Moderate/Severe**	**Severe**	**Minor/ Moderate**	**Minor - Severe**
Displace Businesses	*	**Moderate/Severe**	**Severe**	**Minor/ Moderate**	**Minor - Severe**
Farms	*	-	-	-	-
Disrupt Community Growth	*	**Moderate/Severe**	**Severe**	**Minor/ Moderate**	**Minor - Severe**
Disrupt Regional Growth	*	**Moderate/Severe**	**Severe**	**Minor/ Moderate**	**Minor - Severe**

* No impacts unless Dam Failure

2.7 Environmental Commitments.

1. The Corps commits to surveying exposed shorelines of Lake Cumberland for any caves that appear to be suitable for bat occupation. If caves are found to be inhabited, the Corps will consult with the USFWS to determine the best method of relocating and/or excluding bats from the cave/s.

2. Interested parties will be kept informed of current information regarding all aspects of the Wolf Creek seepage rehabilitation construction project via the Corps, Nashville District website.

3. The Corps will abide by a proposed Programmatic Agreement (described in Section 2.5.8), that will address adverse effects to historic properties, if/when it is signed by applicable parties.

4. The Corps will continue to monitor water quality to determine effects of Cumberland River Reservoir System operations. Monitoring data is immediately used in decision making processes and is provided to affected parties (mostly agencies).

5. The Corps will continue to consult with federal and state fish and wildlife agencies throughout the Wolf Creek Dam construction process, regarding environmental issues.

6. The Corps commits to installing orifice gates over the entrances of sluice gates at Wolf Creek Dam (as described in Section 2.5.1)

7. The Corps will strive to maintain or complete all other mitigation activities (as described in section 2.5).

2.8 Environmental Justice. Executive Order 12898 requires that extensive outreach and opportunity for involvement will address concerns of all communities and that minority residents and low-income residents receive fair and equitable consideration for any potential adverse health and environmental effects from proposed actions. Neither the No Action alternative nor the decision to lower the pool would have an effect on environmental justice.

3.0 Affected Environment (Baseline Conditions).

The immediate project area for the lake level and dam alteration is Lake Cumberland and Wolf Creek Dam, and the tailwaters. However, the impacts of altering the established guide curves have consequences that reach far beyond the immediate lake. River flows, water quality, water temperature, and economics, just to name a few, will be impacted throughout the length of the Cumberland River Valley. This section describes the physical, biological, social, historic property, and economic resources in the Cumberland River Basin that could be affected by the proposed action.

3.1. Environmental Setting and Physiography. The climate of the area is distinctly continental with moderate temperatures averaging about 60 degrees Fahrenheit and rarely exceeding 100 degrees Fahrenheit or falling below zero. The length of the average growing season is about 210 days, extending from early April to the end of October. Annual precipitation for the basin averages 45 to 50 inches.

The dam lies within Ecoregion 71, the Interior Plateau, (EPA Ecoregions 2004). Ecoregion 71 varies from mountainous areas in the eastern sections to rolling plateau, undulating plains, hills, and karst. Deep, narrow valleys through which creeks and rivers flow cut the area. Near the Cumberland River steep bluffs, springs, cascades, and wide bottomlands occur. Most of the agricultural land lies on top of the plateau, although historically even relatively steep hillsides were cleared and farmed. The bedrock of the basin is Paleozoic Age with sandstone, limestone, shale, coal, and conglomerate members. The natural vegetation is primarily oak-hickory forest. Streams have a moderate gradient with productive, nutrient-rich waters. Rainfall averages between 48 and 56 inches per year.

Virtually all lands suitable for farming in the river valleys have been utilized for agriculture since settlement in the early nineteenth century, although farming many of the hillsides by modern mechanized methods would be impractical. The hills too steep for cultivation or pasture were allowed to remain forested, and the usable timber on them has been harvested periodically. Early commercial uses of the rivers were for transportation of merchandise by boat, and floating log rafts to downstream markets.

3.2. Hydrology and the Cumberland River Reservoir System. The Corps constructed and operates ten dams and reservoirs within the Cumberland River Basin (see Figure 5). These dams were authorized and constructed at different times for different purposes. Barkley, Cheatham, Old Hickory, and Cordell Hull Dams are located on the mainstem of the Cumberland River with navigation locks that cumulatively, provide 452 miles of navigation from the mouth of the Cumberland River up to Celina, Tennessee. In addition to navigation, Barkley Dam has water storage capacity. Wolf Creek Dam spans the Cumberland, but does not permit navigation. Wolf Creek has a significant water storage capacity. The Cumberland River tributary dams are Martins Fork Dam, on Martins Fork; Laurel Dam, on Laurel River; Dale Hollow Dam on the Obey River; Center Hill Dam on the Caney Fork River; and, J. Percy Priest Dam on the Stones River.

Figure 5 - Cumberland River System of Reservoirs

The 10 projects are managed as one system with the goal of managing the flow of water through the entire Cumberland River basin. This systems approach manages the Cumberland River flow to be held or released at different projects depending on climatic conditions within the river basin. During floods, water is stored and then time released to minimize damage downstream. During typical and dry years, water releases are coordinated to ensure that enough water flows to meet downstream needs.

Only three dams sustain the desired Cumberland River flows through Barkley Dam during drought. Wolf Creek, Dale Hollow, and Center Hill Dams supply 69%, 15%, and 16%, respectively, of the total flow in the Cumberland River system. The ability of a project to contribute flow to the system is linked to the summer pool storage elevation maintained at a Wolf Creek, Dale Hollow and Center Hill projects.

Wolf Creek Dam was authorized in 1938 and constructed in the 1940s. The following description would be for conditions at Lake Cumberland under normal operating conditions. It has a drainage area of almost 6,000 square miles. At the top of the power pool (elevation 723 ft), Wolf Creek's reservoir (Lake Cumberland) is 50,250 acres and the volume is 3,995,000 acre-ft. At the top of the flood control pool (elevation 760 ft), it is 101 miles long with a surface area of 63,530 acres and volume of 6,089,000 acre-ft. The nominal residence time of the water, i.e., the theoretical time the water remains in the lake before being discharged, is 129 days.
The Wolf Creek tailwater extends for approximately 80 miles from Wolf Creek Dam at CRM 460.88 to the headwaters of Cordell Hull Reservoir at CRM 380-390 (actual river mile depends on reservoir level). Local drainage area along the 80-mile tailwater upstream of the Obey River confluence is approximately 400 square miles. The tailwater impacts are felt much farther.

Impoundment of Wolf Creek Dam created a deep lake and altered the river downstream of the dam by significantly lowering the water temperatures and changing the daily flows. The consequences of impoundment were the conversion of a diverse cool water stream, along with most of the fish and aquatic life it supported including a number of now endangered species of freshwater mussels, into a cold water reservoir with a cold tailwater.

3.3. Water Quality. Hydropower (also regional power), recreation, fish and wildlife, and water supply are all impacted to some degree by water quality. In turn, water quality is directly impacted by a combination of hydrologic, temperature, and reservoir system operation variables. While in an academic setting, water quality is defined as the physical, chemical, and biological characteristics of water, this discussion is focused on only two parameters; temperature and DO.

Once a river is dammed and a reservoir is created, processes such as stratification, seasonal turnover, chemical cycling, and sedimentation can intensify to create several non-point source pollution problems. These processes occur primarily as a result of the presence of the dam, not the operation of the dam (EPA: Guidance

2004). The extent of changes in downstream temperature and DO from reservoir releases depends on the retention time of water in the reservoir and the withdrawal depth of releases from the reservoir. Storage reservoir releases are usually colder than inflows. Reservoirs with short hydraulic residence times have reduced impacts on tailwaters (EPA: Guidance 2004).

Lake Cumberland is a deep, clear lake, which undergoes strong thermal stratification from mid-spring until mid-fall. The main channels of the lake tend to be mesotrophic, while the major embayments are eutrophic. During the period when the lakes are stratified, depletion of DO occurs below the epilimnion in the major embayments with large inflows and in the metalimnion (thermocline) and benthic zones of the main channels. DO levels are too low to sustain most fish and invertebrate life below the epilimnion in these embayments.

With the exception of low DO during the stratified periods, the quality of the releases flowing through Wolf Creek is good since this water is largely drawn from winter stored water from deep in the project. The theoretical hydraulic retention time, varying considerably, is 129 days. This water is cold and low in dissolved and settleable solids, however, the released water can be low in DO in the summer through early fall. There are no known pollutants in the releases.

Many factors affect water quality including the amount of rainfall. As the water is retained in a deep lake, it tends to cool. High inflows reduce the retention time in the lake. In addition, Wolf Creek Dam was constructed to draw water from the lower, cooler levels of the reservoir because that is the most efficient design for a hydropower plant. In wet years, then, the lowered retention times and the discharge of cold water to make room for the incoming warmer water occasionally makes it difficult to attain sufficient cold water storage. Warmer water sometimes results in the deaths of some of the cold water fish like walleye, hybrid stripped bass, and trout.

In dryer years, the opposite is true. The water is retained for longer periods and becomes quite cold. However, because there is little inflow, there is little water available for release. Low releases equate to low flows in the river downstream. In Cordell Hull, Old Hickory, and Cheatham Lakes the situation becomes critical at times during the summer. The flows become stagnant, the water heats, and the DO plummets.

At times, particularly during the summer months, water in Old Hickory and Cheatham Lakes can become stagnant and suffer from low DO and other water quality issues. To prevent these problems the Corps has identified mean monthly flows of 7,600 cubic feet of water per second (cfs) in June, 9,100 cfs in July and 9,400 cfs in August, from Old Hickory Dam to support water quality conditions in the Cumberland River. Water released from Wolf Creek accounts for 69% of the water required for these releases. In 1975 when Lake Cumberland was lowered to effect repairs on Wolf Creek Dam, there was little water for release. Due to the lack of water, discharges from Old Hickory Dam for June, July, and August of 2007, were limited to 1,993 cfs, 1,779 cfs, and 1,950 cfs, respectively, and the DO in the Old Hickory releases dropped to 2.1 mg/l.

3.4. Aquatic Resources.

Prior to impoundment the Cumberland River supported highly diverse assemblages of fish and aquatic life. Fisheries managers often refer to upper reaches of similar streams as smallmouth-rock bass streams. The streams were known for their extensive freshwater mussel beds that were exploited by local residents seeking freshwater pearls. Since no aquatic survey data is available prior to the construction of dams, we must extrapolate from surveys of similar rivers.

Streams like the Cumberland River characteristically had game fish species, smallmouth bass (*Micropterus dolomieu*) and spotted bass (*Micropterus punctulatus*) in its upper reaches and largemouth bass (*Micropterus salmoides*) occupying the warmer lower reaches. "Sunfish" would include rockbass (*Ambloplites rupestris*), white crappie (*Pomoxis annularis*), longear sunfish (*Lepomis megalotis*), bluegill (*Lepomis macrochirus*), green sunfish (*Lepomis cyanellus*), warmouth (*Lepomis gulosus*), and various sunfish hybrids. Other fish species included channel (*Ictalurus punctatus*), flathead (*Pylodictis olivaris*), and bullhead (*Ameiuris spp.*) catfish. The list of pre-impoundment fish would include many other species such as minnows and shiners (*Cyprinidae spp.*), darters (*Percidae spp.*), sculpins (*Cottidae spp.*), various members of the sucker family (*Catostomidae spp.*), and probably some uncommon species.

Once Wolf Creek Dam was constructed the seasonal flows, water temperature, and water quality changed radically. Upper tailwater temperatures remain between 6 and 10 degrees Centigrade (43 to 50 degrees Fahrenheit) for much of the year. This would approach the winter average of a free flowing stream. Cold discharges and highly variable flows from the dams have created an environment, within the upper tailwater of Wolf Creek Dam, which can be tolerated by only a few native species of fish and aquatic invertebrates. Presently, the fish community in the tailwater is composed of remnants of the pre-impoundment populations, but include artificially propagated, stocked rainbow and brown trout, and species reaching the tailwater by way of entrainment from the lakes during operation of the turbines and spillways. Seasonally, however, walleye, sauger, and white bass enter the tailwater and congregate near the dam in the winter and early spring. Gizzard shad (*Dorosoma cepedianum*) and threadfin shad (*Dorosoma petenense*) provide the bulk of forage for predatory species. Rockfish (*Morone saxatilis*) and white bass-rockfish hybrids, originating from fingerlings stocked in the Cumberland River, are increasingly taken in the lower reaches. Several rough fish species are common, including carp (*Cyprinus carpio*), buffalo (*Ictiobus spp.*), river herring (*Clupeidae spp.*), and drum (*Aplodinotus grunniens*), while channel and flathead catfish are also caught. Invertebrate populations of the tailwaters increase in diversity in direct proportion to distance from the dam. The species found nearest the dams are akin to communities occurring in natural springs. Isopods of the genus *Lirceus*, amphipods (Gammaridae), and midges (Tendipedidae) are the most frequently encountered groups. Mayflies (*Ephemeroptera spp.*), stoneflies (*Plecoptera spp.*), and caddisflies (*Trichoptera spp.*), crayfish (*Decapoda spp.*), and small populations of freshwater mussels (*Unionidae spp.*) are present in the down stream reaches.

Beginning in the 1950s, the tailwater was periodically stocked with rainbow trout (*Oncorhyncus mykiss*). Later brown trout (*Salmo trutta*), were stocked each year. These fisheries have grown steadily in popularity and complement the recreational fisheries of the reservoirs.

In 2004 Wolf Creek's tailwater was modeled to help determine the optimum minimum flows necessary to maintain water quality, recreation, and a sustainable aquatic community. The investigation considered continuous flows, pulsed flows, and reregulation weirs. The findings can be found in the *Wolf Creek Tailwater Modeling for Minimum Flow Evaluation* (Loginetics 2004).

3.5. Upland Vegetation and Wildlife. Land use in the drainage basin above the lake consists of forestry, mining, agriculture, urban, industrial, and recreational uses. Runoff from these land uses directly affects the water quality of the lake. Mining, agriculture, and urban development in particular contribute nutrients that affect the requirements in the lake.

Prior to acquisition by the federal government, the lands now surrounding the lake were often burned to remove unwanted stubble and to regenerate growth of wild grasses. As a result of this burning, fire scars may still be seen on older trees. Consequently, these trees are of little commercial value. Forests in the area have been repeatedly cut and high graded and are comprised mostly of oak, hickory, poplar, ash, and eastern red cedar. Because of the change in land practices brought about by federal management, good stands, particularly of yellow poplar (*Liriodendron tulipifera*), now occupy the heads of coves and abandoned fields. The lake receives a high degree of recreational use. Where the terrain is steep around the lakes, most of the public lands receive very little use. Undeveloped public lands predominantly consist of maturing mixed hardwood forests, which are separated from open fields on adjacent private property by borders of fencerows lined with secondary growth. A small percentage of the lands are leased to adjacent landowners for hay and/or grazing purposes and provide a small amount of open field habitat.

3.6. Hydroelectric and Fossil Fuel Power Production. Hydropower was one of the two originally authorized project purposes. The electrical energy produced by the project is sufficient to supply the needs of an average city with a population of 375,000 and it returns about $14 million in hydropower revenues to the Treasury annually. The daily generation schedule typically follows the peak demand for power, which occurs in morning and evening in winter, and afternoons in summer. Wolf Creek has six 45-megawatt (MW) turbines, for a total hydroplant capacity of 270-MW. Peak flow capacity through the turbines is approximately 24,000 cfs.

Center Hill has three 45-MW turbines, for a total hydroplant capacity of 135-MW. Peak flow capacity through the turbines is approximately 12,000 cfs. The Barkley Power Plant has four units, each of which is capable of producing 35,000-MW for a total of 140-MW with an approximate discharge of 38-40 thousand cfs. Cheatham is a low-head dam and as such has limited capacity. Cheatham's three units are rated at 12-MW each or about 36-MW total capacity. Its discharge through the generators is limited to about 21,000 cfs, and it often resorts to spilling water through its gates. Old Hickory Dam has four generators that are rated at 25-MW each. It, therefore, has a combined capacity of about 100-MW. Discharge through the generators is approximately 27-30 thousand cfs. Cordell Hull Dam has three generators rated at 33-MW for a combined output of 99-MW. It discharges between 26 and 28 thousand cfs when all of its units are running. Laurel Dam has 1 generator rated at 70 MW.

Barkley, Cheatham, Old Hickory, and Cordell Hull Dams are primarily dependent on Wolf Creek for their generating water. The power plants at J. Percy Priest, Dale Hollow, Center Hill and Laurel River Dams are not directly impacted by the outputs of any of the other Corps dams. Martins Fork Dam does not have any hydropower production capability (see figure 5).

Hydropower generated at the Cumberland River Basin plants is marketed by the SEPA. In a 1984 Memorandum of Understanding between SEPA, TVA, and the Corps of Engineers minimum weekly energy goals were established. Since that time the CE has an excellent track record of meeting these hydropower goals. See Table 2 for a listing of the minimum energy requirements.

Table 2
Cumberland Basin Projects
Weekly Minimum Energy

Month	Minimum Energy (MWH)
January	24,000
February	29,400
March	32,000
April	32,000
May	22,600
June	24,600
July	32,200
August	32,200
September	21,000
October	15,800
November	16,000
December	20,000

While Cumberland system hydropower is valuable from a peak demand perspective it is the two TVA coal-fired plants, Cumberland City and Gallatin, that provide a significant amount of the base load capacity needed for this region, including the City of Nashville. The Gallatin plant has a coal-fired capacity of 1040 MW and an additional 340 MW from a gas (or diesel) fired generator. The Gallatin plant requires around 1,300 cfs for cooling water. The Cumberland City plant is larger – it has a capacity of 2,517 MW and a cooling water flow of about 4,000 cfs. Gallatin and Cumberland City combined provide more than 10% of TVA's total system capacity. The main unit at Cumberland City is the largest in the TVA system. The Gallatin plant can provide enough generation to supply 300,000 homes.   Likewise, the John Sherman Cooper Power Plant, owned and operated by the East Kentucky Power Cooperative, located on Lake Cumberland is the primary source of power for the Eastern Kentucky region. It has a total capacity of 336 MW.

3.7. Flood Control. Flood damage reduction is one of the originally authorized project purposes. The project is an integral part of the coordinated system for flood protection in the Cumberland and Ohio River Valleys. It significantly reduces flood stages at Nashville, Tennessee, the major damage center on the river, and contributes to flood damage reduction as far downstream as the lower Mississippi River. Wolf Creek Dam is estimated to prevent more than $33 million in flood damages annually.

Barkley, J. Percy Priest, Center Hill, Dale Hollow, and Martins Fork Dams were also partially justified on the basis of flood damage reduction. Cheatham, Old Hickory, and Cordell Hull were not designed for flood control. Nevertheless, all of the lakes are necessarily operated as a single system. The Cumberland River system must also be coordinated with the Tennessee River system operated by the TVA, particularly as Lake Barkley and Kentucky Lake are connected by an uncontrolled canal. These two rivers are, in turn, coordinated with the Ohio and Mississippi River flows.

Lake Cumberland is primarily regulated for the purpose of flood control and hydropower, although recreation, water quality, water supply, and fish and wildlife are also authorized project purposes. The general result of such regulation is a seasonal variation in the reservoir surface elevations. The general pattern is to lower the reservoir to near the bottom of the power pools by November. Winter and spring runoff events result in peak reservoir surface elevations between April and June. Floods are held in the reservoirs until the Cumberland River water levels recede to non-damaging levels at which time the flood storage volume is discharged. Then, beginning in June, the reservoir levels are gradually lowered throughout the summer and fall. Releases are usually made through the turbines for power production.

3.8. Air Quality. The air quality in the region is generally good and is normally in attainment or unclassifiable for all state and national ambient air quality standards (NAAQS).

3.9. Wetlands. The dam site and switchyard is a highly developed, completely artificial area. The site was examined for jurisdictional waters of the U.S., including wetlands, through a combination of in-house research and field investigations. In-house research included a review of published information sources such as U.S. Geologic Survey 7.5-minute quadrangle topographic maps and U.S. Department of Agriculture Soil Conservation Service soil survey maps. Subsequent to the in-house review, the site was examined using the Routine On-Site Determination Method as defined in the 1987 Corps of Engineers Wetlands Delineation Manual. This technique uses a multi-parameter approach, which requires positive evidence of three criteria: hydrophytic vegetation, hydric soils, and wetland hydrology. No jurisdictional wetlands were found on the site.

Dam construction may have deprived wetlands and shorelines of enriching sediments, changed the ability of natural systems to both absorb hydraulic energy and filter pollutants from surface waters, and caused interruptions in the different life stages of aquatic organisms (EPA: Guidance 2004). As these changes would have occurred more than fifty years ago, none of this was documented.

Still, upstream of Wolf Creek Dam, shallow water habitat exists along the shoreline and in various embayment streams. However, under normal conditions, these habitats are variable and only temporary because of the frequent raising and lowering of water levels.

3.10. Threatened and Endangered Species. Several species known to reside in the region around Lake Cumberland or in the tailwater are listed as either threatened or endangered by state or federal agencies. Several bird species such as the peregrine falcon (*Falco peregrinus*) and the bald eagle (*Haliaeetus leucocephalus*) which have recovered and been delisted may transit or migrate through the area. The golden eagle (*Aquila chrysaetos*), and the gray (*Myotis grisescens*) and Indiana (*Myotis sodalis*) bats may also occasionally visit the area. A few mussels may still survive in the tailwaters. Many of the records are based on old, weathered shells. Based on information provided by the US Fish and Wildlife Service, these mussels do not reproduce in the temperatures that currently exist below the dam. If any still survive it is unlikely that they are reproducing. A list of endangered species with records within the project area are found in Table 3.

Table 3
Federally Listed Species Recorded
in the Lake Cumberland Project and Tailwater Area

Scientific Name	Common Name	Status
Alasmidonta atropurpurea	Cumberland Elktoe	Listed Endangered
Apios priceana	Price's Potato-bean	Listed Threatened
Arabis perstellata	Braun's Rockcress	Listed Endangered
Astragalus bibullatus	Pyne's Ground-plum	Listed Endangered
Charadrius melodus	Piping Plover	Listed Endangered
Cumberlandia monodonta	Spectaclecase	Candidate
Cyprogenia stegaria	Fanshell	Listed Endangered
Dalea foliosa	Leafy Prairie-clover	Listed Endangered
Dromus dromas	Dromedary Pearlymussel	Listed Endangered
Echinacea tennesseensis	Tennessee Coneflower	Listed Endangered
Epioblasma brevidens	Cumberlandian Combshell	Listed Endangered
Epioblasma capsaeformis	Oyster Mussel	Listed Endangered
Epioblasma florentina walkeri	Tan Riffleshell	Listed Endangered
Epioblasma obliquata obliquata	Catspaw or Purple Cat's Paw	Listed Endangered
Etheostoma boschungi	Slackwater Darter	Listed Threatened
Hemistena lata	Cracking Pearlymussel	Listed Endangered
Lampsilis abrupta	Pink Mucket	Listed Endangered
Lesquerella globosa	Short's Bladderpod	Candidate
Lesquerella perforata	Spring Creek Bladderpod	Listed Endangered

Table 3 – Continued

Scientific Name	Common Name	Status
Lexingtonia dolabelloides	Slabside Pearlymussel	Candidate
Myotis grisescens	Gray Bat	Listed Endangered
Myotis sodalis	Indiana Bat	Listed Endangered
Notropis albizonatus	Palezone Shiner	Listed Endangered
Noturus stanauli	Pygmy Madtom	Listed Endangered
Obovaria retusa	Ring Pink	Listed Endangered
Orconectes shoupi	Nashville Crayfish	Listed Endangered
Pegias fabula	Littlewing Pearlymussel	Listed Endangered
Phoxinus cumberlandensis	Blackside Dace	Listed Threatened
Plethobasus cicatricosus	White Wartyback	Listed Endangered
Plethobasus cooperianus	Orange-foot Pimpleback	Listed Endangered
Pleurobema clava	Clubshell	Listed Endangered
Pleurobema plenum	Rough Pigtoe	Listed Endangered
Pseudanophthalmus colemanensis	A Cave Obligate Beetle	Candidate
Pseudanophthalmus fowlerae	Fowler's Cave Beetle	Candidate
Pseudanophthalmus inquisitor	Searcher Cave Beetle	Candidate
Pseudanophthalmus insularis	Baker Station Cave Beetle	Candidate
Ptychobranchus subtentum	Fluted Kidneyshell	Candidate
Quadrula sparsa	Appalachian Monkeyface	Listed Endangered
Sterna antillarum athalassos	Interior Least Tern	Listed Endangered
Villosa trabalis	Cumberland Bean	Listed Endangered

3.11. Archaeological, Historical, and Cultural Resources. Section 106 of the National Historic Preservation Act requires Federal agencies to take into account the effect of their undertakings on historic properties. Historic property means any prehistoric or historic district, site, building, structure, or object included in or eligible for inclusion in the National Register of Historic Places. The term includes artifacts, records, and remains that are located within such properties. The term also includes properties of traditional religious and cultural importance to an Indian tribe. Regulations at 36 CFR 800 define a process for taking such effects into account.

The record of human settlement along the upper Cumberland River in south-central Kentucky dates back to at least 8,000 to 10,000 B.C. However, our understanding of Native American prehistory in the Cumberland River watershed stands in stark contrast to what is known from surrounding regions. This is reflected in the dearth of sites that have seen any level of study beyond identification. Prior to the construction of Wolf Creek Dam, relatively few major archaeological studies had been conducted; and since the creation of Lake Cumberland much of the archeological record in the watershed now lies submerged beneath its waters.

Cultural Overview. Native Americans first entered the Cumberland River valley at least 12,000 years ago. Since that time, the region has experienced several major changes in the cultural traditions of its residents. As in other areas of the Kentucky, human occupation is generally divided into five broad cultural-chronological periods: Paleo-Indian (10,000-8,000 B.C.), Archaic (8,000-1,000 B.C.), Woodland (1,000 B.C.-A.D. 1000), and Mississippian (A.D. 900-1000 - 1700-1750), and Historic (A.D. 1700-present).

Prehistoric Period. The earliest period of human occupation in the region is referred to as the Paleo-Indian Period. This period dates from approximately 12,000 to 10,000 B.c. and represents the first clear evidence of humans in the southeastern United States. The origin of the Paleo-Indian Period is the subject of much debate, and there is evidence to suggest earlier human occupation of the North American continent. It is hypothesized that Paleo-Indian groups were small, nomadic bands who used a specialized tool kit for the procurement of now extinct megafauna. However, it has become increasingly apparent that the Paleo-Indian subsistence base was more diverse than originally thought.

The transition from the Paleo-Indian to the Archaic Period was associated with a major climate change that occurred at the end of the last Ice Age. The formerly cooler, moister climate gradually shifted to an ecologically more productive, warmer, and drier climate, closer to what exists today. Subsistence during this time period changed along with the environment as many larger mammals became extinct and dietary patterns generally reflected a reliance on a wider variety of modern species of plants and animals. As glacial recession continued and deciduous forests expanded, the gradual adaptation to a warmer, post-Pleistocene environment is reflected in the tools associated with the Archaic Period. More specialized hunting techniques were also developed, including a shift from fluted projectile points to side-notched and stemmed points.

The transition between the Archaic and Woodland Periods is characterized by an increase in population and sedentism. Concomitant with the increase in population were trends toward greater regional specialization and adaptation. The Woodland Period featured new material and cultural features, including earthwork construction, technological advances in pottery, food processing, and storage. The introduction of pottery into the artifact assemblage around 1,000 BC typically characterizes the beginning of the Woodland Period. Innovations in ceramic types have become a significant basis for dating deposits within the Woodland Period. It is during this period that the distinctive Adena and Crab Orchard cultures emerge.

The Mississippian Period is characterized by distinctive ceramic vessel forms, the use of ground shell as a tempering agent in ceramics, rectangular structures, and ceremonial earthwork complexes. The latter include flat-topped pyramids used primarily as bases for wooden ceremonial structures and high status burials with ceremonial grave goods. Many of these grave goods have a shared iconography that is often referred to as the Southeastern Ceremonial Complex. The Mississippian Period is also characterized by the emergence of chiefdoms, some of which appear to have controlled fairly large areas. The chiefs at the head of these polities controlled the redistribution of food stuffs. They may have also controlled the exchange of goods within their territory and with other chiefdoms, employed full-time specialists, and functioned as both religious and political leaders.

Historic Period. The Historic Period generally is divided into six temporal periods, beginning with Pre-Settlement Exploration (1750-1775). Early French exploration of the area that is now Kentucky never succeeded in establishing any permanent settlements and it would not be until the late 18th century, with the purchase of the lands west of the Appalachians from the Cherokee and Iroquois, that Euro-American settlement began in earnest. This Early Settlement sub-period (1775-1820/1830) is marked by the initial development of infrastructure as well as by conflict with the British and various aboriginal groups. The succeeding Antebellum sub-period (1820/1830-1861) was one marked by continued development and sustained growth of Kentucky's agricultural economy. During the Civil War (1861-1865) Kentucky was a border state and remained officially neutral throughout the war. Overall, the war did not impact the Kentucky to the same extent as states further south and east. Postbellum, Readjustment, and Industrialization (1865-1915) saw the restructuring of the agricultural labor system, the integration of the railroad network, as well the development of the lumber and coal industries. However, despite the rapid industrialization in many parts of the country, Kentucky remained largely rural and dependent upon its agricultural economy. The state would continue to lag behind the rest of the nation in economic development during the period of Industrial and Commercial Consolidation (1915-1945). Agricultural stagnation, the Great Depression, and prohibition would all conspire to have a negative impact on the state, while the automobile age and the development of roads would help spur the growth of industry and tourism during the latter part of the twentieth century.

Wolf Creek Dam/Lake Cumberland History. Authorized by the Flood Control Act of 1938 and the Rivers and Harbors Act of 1946, the ground breaking ceremonies for the construction of the Wolf Creek Dam were held on Labor Day, September 1, 1941. The dam was constructed as part of a comprehensive plan to develop the Cumberland River Basin. Some of the primary motives for construction of the dam included flood control and hydroelectric power generation. Other additional benefits included promotion of recreational activities and water supply services. Construction of the dam led to the formation of Lake Cumberland, the largest manmade reservoir east of the Mississippi River. Due to the impacts on the nation from World War II, construction of the dam was temporarily suspended during the 1940s. The dam was finally dedicated by Vice President Alben Barkley in September 1951.

Wolf Creek Dam, and original facilities associated with this structure, is considered eligible for listing on the National Register of Historic Places. This was one of the first large, multi-purpose dam and reservoir projects in the Cumberland River basin providing significant flood control, hydropower, and recreational benefits to the region. The project was conceived in the period before World War II and its construction and completion were shaped by that conflict.

Submerged Towns/Communities. The creation of Lake Cumberland led to the submergence and/or relocation of several communities located along Cumberland River.

These communities were primarily located in the counties of Russell, Cumberland, Wayne and Pulaski. Some of these communities included Long Bottom, Lula, Horse Shoe Bottom, Stokes, Creelsboro.

Archeological Resources. A total of 148 archaeological sites have been recorded previously on Corps of Engineers fee-title lands in the Wolf Creek Dam/Lake Cumberland project area. Of this total, only 36% (n = 53) are located below the summer pool elevation (723' AMSL); the remaining 95 previously recorded sites are located on Corps of Engineers fee-title lands and have never been inundated by the Lake. Approximately 23.6% of the previously recorded archaeological sites (n = 35) are completely submerged at this time (i.e., below 670' AMSL). A total of 18 previously recorded sites occur between the current drawdown elevation and maximum summer pool elevation (i.e., 670'-723' AMSL); only two of these previously recorded sites fall within the winter pool elevation and the current drawdown level (670'-690' AMSL).

Subsequent to the drawdown of the Lake Cumberland pool to the 680’ elevation the Corps contracted for an archeological reconnaissance and assessment survey of selected areas along the newly exposed shoreline. This assessment comprised a 1.1% sample of the shoreline. As a result of the survey 39 archeological resources were identified, including 31 new sites and 8 previously recorded sites. Site types from newly discovered and revisited sites include late 19th and early 20th century farmsteads and/or residences, and prehistoric lithic scatters representing Early Archaic through Woodland Period occupations. Eleven of these archeological sites are considered potentially eligible for listing on the National Register of Historic Places. Despite having been inundated and exposed to erosion these sites appear to have some degree of depositional integrity and therefore could contain cultural features and/or artifact distribution patterns useful for understanding upland and riverine site occupation and settlement in the Cumberland River region. The assessment survey indicates that numerous previously recorded sites were exposed by the drawdown and many sites that have not been recorded were also exposed. Although it is hazardous to extrapolate from current survey results to the lake as a whole, it is very likely that several hundred archeological sites have been exposed to adverse impacts as a result of the drawdown. Most sites located within the drawdown area may not be considered historic properties eligible for listing on the National Register; however, that determination would require survey and individual site evaluation. Newly exposed archeological properties, both prehistoric and historic, have been extensively subjected to the illegal collection of artifacts in violation of the Archeological Resources Protection Act.

3.12. Noise. Most of the noise associated with operating a hydropower plant is contained within the structure. The remainder is localized and incidental. Due to a lack of receptors, noise is not currently a factor at the project site. The exception is warning horns that sound prior to beginning generation to notify those downstream of the impending release. The other main source of noise is the highway. Currently the Kentucky Department of Transportation is studying relocating the highway from its current location on top of the dam. Doing so would lower the current noise level, but is not a focus of this study. It should be noted that most areas around the immediate dam site and around the majority of Lake Cumberland, areas are mainly rural and natural. These areas would be considered quiet and low on noise levels.

3.13. Recreation. Recreation was not originally an authorized project purpose. The Federal Water Project Recreation Act of 1965 established development of the recreational potential at federal water resource projects as a full project purpose. Recreation has become a major factor in the regional economy. Because of the temperate climate and relatively long recreation season, visitors have many opportunities to fish, hunt, camp, picnic, boat, canoe, hike, and enjoy the outdoors. Lake Cumberland supports 52 recreation areas, 48 improved boat launching ramps, 390 picnic sites, 18 playgrounds, 4 swimming areas, 24 trail miles, 2 fishing docks, 48 boat ramps, 11 marinas, 4,301 marina slips, two state parks, and six US Forest Service Areas. Approximately 4.5 million people visit the lake annually. See table 4 for a breakdown by month of estimated visitation since 2005.

Table 4
Lake Cumberland Visitation

Month	FY 2005 Visitation	FY 2006 Visitation	FY 2007 Visitation
October	304,569	287,719	348,226
November	292,460	274,668	248,444
December	181,287	178,244	235,466
January	127,746	125,875	149,539
February	159,083	159,951	162,204
March	274,155	178,525	247,539
April	352,983	341,901	318,495
May	526,124	483,328	362,483
June	770,183	610,864	502,643
July	848,589	722,826	553,410
August	701,011	636,529	
September	314,960	411,705	
Total	**4,853,150**	**4,412,135**	

Wolf Creek Dam tailwater provides cold water habitat that supports a put-and-take trout fishery. The Kentucky Department of Fish and Wildlife Resources (KDFWR) monitors and stocks 75.2 miles of trout fishing in the Cumberland River below Wolf Creek Dam. The most noteworthy attributes of the tailwater are its aesthetic qualities and recreational potential. Recreational fishing and boating, particularly trout fishing and canoeing, are by far the major activities accounting for visitation. Corps facilities at the dam include a campground, boat ramp, comfort stations, picnic pavilion, and playground facilities. Many users camp in conjunction with fishing for trout.

3.14. Economics. The dam is a significant economic factor in the region. The cost to build the project was approximately $80.4 million. In addition to the recreation, hydropower, flood damage reduction, and navigation benefits, the dam provides many other advantages including municipal water supply, increased property values, increased tax revenues, and employment opportunities.

The dam has prevented significant flood related damages over the years. It is estimated that Wolf Creek has prevented more than $1.3 billion in damages. The level of safety provided by the dam has encouraged the development of communities and businesses along the river.

The relatively inexpensive and dependable electricity provided by the power plants has contributed to the region's economic well-being. Wolf Creek Dam annually generates over 1,000,000 MW at an estimated value of more than $7.1 million.

Although recreation was not originally an important consideration and was not an authorized project purpose until passage of the Federal Water Project Recreation Act of 1965, it has become a major economic factor in the region. It's estimated that visitors to the Lake Cumberland area have an economic benefit of approximately $150 million. According to the Kentucky Cabinet for Economic Development, this tourism economy is made up of many types of small businesses that include marinas, house boat manufacturers, house boat repair shops, bait and tackle shops, cabin and hotel lodges, country stores, eateries and diners, resort proprietors and vacation home builders, recreation watercraft dealers, etc.

Since Wolf Creek Dam altered the temperatures of the tailwater from a cool to a cold-water stream; the wildlife agencies have developed a trout fishery in the area. This fishery provides many hours of recreational benefits and has a strong effect on the local economy. According to the Kentucky Department of Kish and Wildlife Resources, the tailwater fishery has a $7.1 million annual economic benefit.

The FWS estimates that the Wolf Creek National Fish Hatchery below Wolf Creek Dam has a direct economic benefit of $50 million annually and an indirect benefit of over $75 million. It returns almost $8 in tax revenues for every tax dollar spent. These benefits include employment, employment income, industrial output and federal and state tax revenue that occur as the result of consumer expenditures on hatchery-related goods and services (FWS 2001).

3.15. Erosion. Erosion of the riparian zone is a common sight along the tailwater. It is a complex process that is typically caused by a medley of natural and man-made factors. The primary cause of the erosion is typically poor land use management. While severe erosion is a problem in some areas, its effects are unknown. Studies by the Corps and an independent consultant with more than 30 years of experience in this area indicate that hydroelectric generation at the dam is not the main cause of this erosion. Some factors believed to contribute to bank erosion are groundwater flow through non-cohesive soils, tightly bending channel geometry, and land use practices including trampling of the banks by cattle and clear-cutting trees and natural vegetation on the banks. The dam allows the regulation of river flows, resulting in a reduction of the large flood events that typically are a major factor in bank erosion. Based on several studies, the dams have probably reduced scouring and erosion of streambanks as a result of reduced velocities in downstream areas (EPA: Guidance 2004).

Controlled releases from dams change the timing and quantity of flows. The tendency of dam releases to be clear water, or water without sediment, can result in erosion of the streambed and scouring of the channel below the dam, especially the smaller-sized sediments (EPA: Guidance 2004). The tailwater area has been scoured for the last fifty years, and although some riffles and shoals still exist, they primarily consist of coarser materials.

Erosion of the shoreline above Wolf Creek Dam is an on-going process. It occurs from a combination of natural erosion, wave-action, and the fluctuation in pool height.

3.16. Aesthetics. The dam is located in a rural location and is surrounded by rolling, wooded hills. The dam itself is comprised of a gray concrete structure and a mowed grass earthen embankment, and topped by a highway. The entire area is cut by deep, narrow valleys through which creeks and rivers flow, and much of the lake shore is extremely steep and has rock wall outcroppings. Various historical features, many associated with the Civil War and other local happenings, are scattered through the area. Significant memorials to major events in the development of the States of Kentucky and Tennessee are within driving distance. In general, this is a region of varied and interesting landscape qualities including forests, agricultural lands, lakes, and small towns and is attractive to the average person.

3.17. Environmental Justice. Executive Order 12898 requires that extensive outreach and opportunity for involvement will address concerns of all communities and that minority residents and low-income residents receive fair and equitable consideration for any potential adverse health and environmental effects from proposed actions. Demographic information of the surrounding area (Clinton, Pulaski, Russell, and Wayne Counties, Kentucky), based on US Census information and other web searches, indicates no differential demographics based on ethnic or cultural factors. The percentage of minority communities in the surrounding area is far below the state and national averages. The poverty level of the region is above the national average (see Table 5).

Table 5
Demographics of Project Area

Location	Population	Minorities Population (%)	Persons below Poverty (%)
Clinton County	9,566	1.1	23.5
Pulaski County	59,749	2.7	18.7
Russell County	17,174	1.1	21.5
Wayne County	20,504	2.4	24.3
Kentucky	4,206,074	9.6	16.3
United States	299,398,484	19.8	12.7

3.18. Navigation. Wolf Creek Dam has no lock, and navigation is not an authorized project purpose. Nevertheless, its regulated stream flow has at times provided some incidental benefits to maintaining navigation on the Cumberland River, lower Ohio River, and the Mississippi River.

3.19. Hazardous, Toxic, or Radiological Waste. At a minimum the dam is inspected annually for any HTRW or other environmental concerns through the Corps' Environmental Guide Review for Operations (ERGO) and OSHA programs. Currently there are no known Hazardous, Toxic, or Radiological Waste (HTRW) concerns in the project study area.

3.20. Traffic. US Highway 127 traverses the top of the dam and serves as a major connection between the two sides of the river. To detour around via the closest bridge will increase the travel distance by over 100 miles. An estimated 1,500 to 1,900 vehicles per day or about 600,000 vehicles per year cross the dam. The Commonwealth of Kentucky's Transportation Cabinet is currently planning to relocate US 127 downstream from the project.

3.21. Safety. Safety is an intrinsic consideration in the planning and operation of the reservoir. One of the authorization purposes for constructing Wolf Creek Dam was to reduce the loss of lives and property from flooding. Maintaining the structural integrity of the dam is, therefore, a project priority.

4.0 Environmental Consequences. There will be a number of negative impacts on the environmental resources and economics of the decision to modify the lake levels in Lake Cumberland. This section describes the foreseeable impacts of the decision, but in no way should be interpreted as capturing all potential circumstances and associated impacts. Many impacts would be felt throughout the Cumberland River Valley.

4.1. Environmental Setting and Physiography. None of the alternatives will have significant impact on the physiography or climate of the area.

4.2. Hydrology and the Cumberland River Reservoir System. Wolf Creek Dam and Lake Cumberland is, in many ways, the pivotal project for the entire Cumberland River System. As noted above, water for electric power production, water quality, etc. is provided by stored water in Lake Cumberland. The operation of the main stem lakes Barkley, Cheatham, and Cordell Hull Lakes will be restricted without Lake Cumberland's stored water. The tributary lakes, i.e., J. Percy Priest, Center Hill, and Dale Hollow cannot completely make up for the shortfall. Although those lakes would not be able to keep up with the demand, there will undoubtedly be an effort to moderate the lack of water in the main stem by extra releases from the tributary lakes. All of those lakes will, therefore, be affected by this decision. Only Martins Fork Lake in the headwaters of Lake Cumberland would be unaffected by the change in operating procedures at Wolf Creek Dam.

Wolf Creek normally contributes up to 69% of the Cumberland River flow. However, under the 2007 risk reduction measure of maintaining the pool at 680 ft, year round, storage in the lake has been reduced approximately 1,885,000 acre-feet (88.0%). Under this condition, the reservoir is unable to supply customary flows. Any single target pool elevation leaves no flexibility for managing Lake Cumberland to optimize purposes above and below Wolf Creek Dam. A lack of flows from Wolf Creek and a drawdown at Center Hill, would put pressure on Dale Hollow Lake to make up adequate flow contributions. It is very likely that Dale Hollow would be unable to meet these demands, even if it is virtually drained itself.

How much water Wolf Creek would be able to store and release to the system under drought conditions is dependant on the alternative selected and weather patterns:

<u>Alternative 1, No Action.</u> The No Action alternative would not have an effect on the amount of water available at Lake Cumberland for release. However, during dam repairs, a dam failure or loss of the pool would eliminate water storage entirely. Water releases would cease and the only water flow upstream of Cordell Hull Dam would come from stored water at Martins Fork and Laurel Reservoirs and natural inflows.

<u>Alternative 2, Maintain Lake Cumberland pool height at 680 ft.</u> Maintaining Lake Cumberland at elevation 680 ft reduces the stored water by 88.0 %. Therefore, it can not supply 69% of the summer water flow to the system, which it would under normal operating conditions. Under this condition the reservoir would be able to supply significantly less flow to the Cumberland River during the summer months (June-October). This increases the pressure for Dale Hollow and Center Hill to supply water flow to the system. In 2007, Dale Hollow stored about 6% more water for release during summer and fall. There are also pool restrictions, and studies to evaluate pool restrictions, currently being conducted on Center Hill Lake. The outcome of those studies will likely restrict water supply release from Center Hill Dam and place further demand from the other reservoirs to supplement flows during the summer.

<u>Alternative 3, Maintain Lake Cumberland pool height at 650 ft.</u> At elevation 650 ft, only the 6 sluice gates would be able to release water. At approximate elevation of 650 ft, the 6 sluice gates only have a release capability of approx. 7500 cubic feet per second (cfs). Therefore, with the reservoir drawn down to this elevation, it would be subject to extreme water elevation changes due to inflows from rain events. Depending on the weather, releases would have to be made in order to draw the lake back down to the target elevation of 650 ft. This would cause high rates of flow below the dam during drawdowns, but not necessarily when it is needed. Under this alternative, similar to Alternative 2, Wolf Creek Dam would be able to provide significantly less flow to the Cumberland River, during the summer months.

<u>Alternative 4, Maintain Lake Cumberland with a partial fill guide curve between 685 and 700 ft.</u> Under this alternative, water flows from Wolf Creek would be less adversely affected than the other "action" alternatives. Operation managers would allow Lake Cumberland to fill to approximately elevation 700 ft by May and then drawn back down to 685 ft by around October. Releases would be scheduled to carry out project purposes (i.e. recreation, hydropower, flood reduction, etc.) to the best ability. Under Alternative

4, Wolf Creek would be able to provide significantly more flow to the Cumberland River during the summer months than alternatives 2 and 3.

Alternative 5, Manage the Cumberland River system in accordance with an Interim Operating Plan. Under this alternative, impacts to water flows and the Cumberland River reservoir System could be similar to any of those described under the other alternatives. This plan would help managers operate the reservoir system to lessen adverse impacts to greatest extent possible regardless of lake level target or guide curve.

Further details of impacts to the system, from individual alternatives, will be outlined in the following sections.

4.3. Water Quality.

The decision to lower the lake to a single target pool elevation (i.e. 680 ft) will likely result in a situation similar to that which occurred in 1975, i.e., it is very possible that there will be little water for release in the summer months and water quality in the Cumberland River will suffer. How severe the situation will be, is primarily dependant on weather patterns and the specific pool elevation. Poor water quality will result in increased water treatment costs for the municipal water intakes as well as impacts to the fisheries, navigation, and power production.

Water quality issues would be more local (Lake Cumberland) in nature when rainfall is greater than normal during the spring and summer (wet weather conditions). The Lake Cumberland cold water budget is at risk of being depleted when large inflow events in the spring or summer require the discharge of cold oxygenated water collected during the winter months. This leads to an increase in water temperature and a more rapid decrease of DO in the lake. During a wet year the water quality impacts downstream of Wolf Creek Dam, to the Cordell Hull, Old Hickory, Cheatham, and Barkley projects, would not be significant due to relatively large flows. The system could be managed to provide an adequate supply and quality of cooling water for both the Gallatin and Cumberland City Fossil Plants. Water quality for water supply impacts would also be expected to be minimal in nature.

Dry weather conditions will provide the best opportunity to support the coldwater fisheries both in the lake and in the river downstream. Dry weather conditions will result in the largest available volume of cold water. This will allow LRN Water Management to only discharge the minimum amount needed to support downstream requirements for water quality and power production, and retain the balance of water to support the coldwater fishery in the lake.

Under extreme drought conditions, severe adverse impacts to water quality can occur in both the lake and downstream tailwater, including the entire Cumberland River. Water temperature would rise in both the lake and tailwater. Cumberland system simulations of drought conditions, using the LRN system water quality model, indicate the need for unit de-ratings or complete shutdown at both Gallatin and Cumberland City Fossil Plants in order to maintain thermal compliance to be a distinct possibility. Old Hickory outflow DO levels would also be expected to fall below the 5 mg/l state standard. In 1975, the Lake Cumberland pool level was held down in conjunction with construction of the diaphragm wall. The lake level at the end of May was 694.3 ft. The pool was gradually drawn down throughout the recreation season reaching an elevation of 681.5 ft around Labor Day. Dale Hollow and Center Hill were both operated in a normal mode. The resulting flows at Old Hickory were very low for the months of June, July, and August. The average flow for each of these three months was <2,000 cfs. LRN did not have established target monthly Old Hickory releases in 1975. It was actually this event that led to the development of a system water quality model and subsequently application of that model to develop flow criteria. The Old Hickory target flows for June, July, and August are 7,600 cfs, 9,100 cfs, and 9,400 cfs, respectively. Grab sample DO data collected from the Old Hickory tailwater documented DO values as low as 2.1 mg/l in August, 1975. This is a level that would result in widespread fish kills. The established water quality standard is a minimum of 5 mg/l for warm water habitat and 6 mg/l for cold water habitat (tailwater immediately below Wolf Creek Dam). The corresponding water temperatures were around 26 ^{o}C, about 1.5 ^{o}C above the Gallatin threshold temperature.

Alternative 1, No Action. The No Action alternative would see a continuation of the scenario described in section 3.3 above. Weather will vary from year to year with an occasional wet or dry year, but on the whole the water releases from Wolf Creek are sufficient to maintain a balance. However, during dam repairs, a dam failure or loss of the pool would alter water quality. Eliminating the Lake Cumberland Reservoir would eliminate cold water storage. The immediate downstream tailwater would revert back to a warm water river and the coldwater fisheries both upstream and downstream of the dam would be eliminated. Warm water does not hold as much DO as cold water. Because of the relationship of the reservoirs on the entire Cumberland River, water quality would likely degrade throughout the Cumberland River.

These adverse impacts to water quality would be possible for all action alternatives described below.

Alternative 2, Maintain Lake Cumberland pool height at 680 ft. With an operational target of elevation 680 ft (2007 target elevation), Lake Cumberland will begin the summer with a significantly reduced volume of cold water in storage. The coldwater fisheries in the lake, primarily stripers and walleye, are dependent on the maintenance of a zone of cold, oxygenated water. Likewise, the tailwater fishery that includes rainbow and brown trout in addition to striper and walleye is dependent on the release of cold, oxygenated water. If the cumulative project releases through Wolf Creek Dam during the summer exceed the volume of cold water in storage, significant fish die-offs would be expected both in the lake and in the river below the dam. A late spring major storm event or a series of spring or summer storms would increase the likelihood of this happening. The only water management option available for the tailwater at Wolf Creek is to use sluice gate releases in lieu of hydropower releases to provide cold, oxygenated water for the tailwater. Sluicing will conserve the zone of cold water in the lake used by important fish species as long as adequate DO is available. This can be effective up to a point, but once the cold water is gone there is nothing that can be done to protect these fisheries.

In 2007, Old Hickory Dam was forced to release significantly lower flows due to the lack of water storage at Lake Cumberland. Flows have totaled 2765 cfs in June, 3230 cfs in July, and 4350 cfs in August. Resulting DO levels have been as low as 2.8 mg/l and an average of 6.2 mg/l during this time.

<u>Alternative 3, Maintain Lake Cumberland pool height at 650 ft.</u> This alternative would have very similar results as the alternative 2; however, conditions could be much worse. The pool would be significantly lower leaving it more sensitive to warm rain inflows and with less cold water storage from winter. Temperatures both in the reservoir and tailwater would be significantly warmer. Warmer waters would hold less DO. A shallower reservoir with warm water would be ideal for large and increased numbers of algal blooms, which cause further declines in DO and problems with taste and odor of drinking water. Since the overall water volume would be significantly reduced, sediments, pollutants, metals, nutrients, etc. would be more concentrated causing problems with municipal water treatment. These problems would likely be experienced throughout the Cumberland River.

<u>Alternative 4, Maintain Lake Cumberland with a partial fill guide curve between 685 and 700 ft.</u> With a partial fill guide curve, operation managers would have more freedom in making cold water releases to best manage project purposes. There would be additional cold water storage in the summer to make releases for the cold water fishery down stream. Adverse impacts similar to those described above, would still be possible, however they would likely be in the minor to moderate range when compared to the other action alternatives.

<u>Alternative 5, Manage the Cumberland River system in accordance with an Interim Operating Plan.</u> All adverse impacts as described above could occur under this alternative. However, under this interim plan, the system would be operated to minimize all adverse impacts to the greatest extent possible. Also, according to the interim operating plan, the system would be operated according to ordered priorities (see paragraph 2.2.5).

<u>4.4. Aquatic Resources.</u> As with many other resources, aquatics would sustain adverse impacts under any of the action alternatives. The significance of those impacts is highly related to climatic variables coupled with the degree of water elevation reduction.

During a wet year, the downstream cold water fishery likely would only sustain minor impacts. However, the cold water habitat in the lake could be highly depleted. There would likely be significant kills of species such as the hybrid stripped bass and walleye within the lake. Also, there would not be adequate cold water storage for the intake to the Wolf Creek National Fish Hatchery and operations there would likely cease. The hatchery provides trout (brown and rainbow) to 47 streams, 14 tailwaters, and 29 lakes in Kentucky. At times the hatchery also provides trout to receiving waters other southeastern states.

A dry summer would cause less adverse impacts. A dry summer would allow for the largest cold water storage. Operators would be able to release the minimum amounts of water to support downstream coldwater habitat, while conserving the lake coldwater habitat. It is likely that impacts to aquatic resources would be minimal to moderate.

Under drought conditions adverse impacts to aquatic resources both above the dam and below the dam could be severe. Extreme warm temperatures sustained over multiple summers would likely lead to a total loss of the tailwater fishery. Also, releases for downstream flow requirements of the Cumberland River, would leave the lake depleted of cold water habitat in essence eliminating the cold water fishery upstream of the dam. Again, like the wet year, the Wolf Creek National Fish Hatchery would likely have to cease operations, without the availability of cold water withdrawals. Warm temperatures, low DO, and low flows would likely adversely affect aquatic resources throughout the Cumberland River

By reducing water elevation by any level for an extended amount of time, there is a loss of shallow water habitat for fish spawning and nursery habitat for juvenile fish. Many fish attractors such as native and man-made log piles and brush, under-cut banks, etc. would be exposed out-of-water, reducing fish cover, particularly for young-of-the-year. However, there could be a long term benefit to the lake’s fishery. With lake levels low, exposed shorelines could be re-vegetated, providing a large addition to habitat for all aquatic species once levels return to historic levels.

<u>Alternative 1, No Action.</u> The No Action alternative would have no significant adverse impact upon existing aquatic resources. Under normal operations, all project purposes and resources are adequately supported for most years. However, during dam repairs, a dam failure or loss of the pool would likely eliminate much of the aquatic resources. The cold water habitat would be eliminated both in the lake and in the downstream tailwater, virtually eliminating all cold water species (i.e. hybrid strippers, walleye, trout, etc.). DO would likely plummet and water temperatures could rise significantly, affecting species throughout the Cumberland Reservoir. Losses from fish kills would likely be immeasurable.

<u>Alternative 2, Maintain Lake Cumberland pool height at 680 ft.</u> A drawdown of Lake Cumberland to elevation 680 ft significantly affects aquatic resources. How severe the impacts are depends on the weather conditions. With an increase of temperature and a decrease in DO (described above) the cold water fisheries above and below the dam suffer. Under this alternative, fish kills are possible and likely. It is possible that in a significantly wet year that the oxygenated, coldwater habitat in the lake could be entirely lost. According to the Kentucky Department of Fish and Wildlife Resources(KDFWR),

if the lake cold water fishery was eliminated, it would take 15 years from the time they restock until the fishery is fully restored.

At elevation 680 ft, the lake is approximately 43 feet lower than it typically would be in May and approximately 15 feet lower than it would be in December and January. This leaves significant portions of the shoreline exposed out-of-water, as stated above this likely eliminates significant fish cover and spawning habitat. Also, it does allow for re-vegetation. Currently, while Lake Cumberland has been held around the 680 ft level, there has already been a large recruitment of vegetation in the newly exposed shoreline. Other impacts associated with different weather scenarios are described in the following paragraphs.

<u>Alternative 3, Maintain Lake Cumberland pool height at 650 ft.</u> Adverse impacts would be even more severe with Lake Cumberland drawn down to 650 ft than elevation 680 ft. At this level, the stored cold water within the lake would most likely not exist under any weather condition. There would be a complete loss of cold water fisheries above and below the dam. The Wolf Creek National Fish Hatchery would be forced to cease operations eliminating 800,000 trout that are stocked to all of Kentucky. It is unknown if trout could be supplied to Kentucky through other means. An enormous amount of acres of fish cover habitat would be exposed out of water, and because of the rapid changes in water depths that are possible under this alternative, it is likely that the exposed areas may not re-vegetate.

<u>Alternative 4, Maintain Lake Cumberland with a partial fill guide curve between 685 and 700 ft.</u> An operating guide curve between 685 and 700 would provide 15 additional feet of storage, increasing the volume of cold water within Lake Cumberland. This allows for operational flexibility in how much water can be released and when. It also provides a buffer in the summer if large inflows of warm water occur as a result to rain events. Impacts that were described above could still occur, however, they would be less severe in nature as compared to alternative 2 and 3.

<u>Alternative 5, Manage the Cumberland River system in accordance with an Interim Operating Plan.</u> All adverse impacts as described above could occur under this alternative. However, under this interim plan, the system would be operated to minimize all adverse impacts to the greatest extent possible. Also, according to the interim operating plan, the system would be operated according to ordered priorities (see paragraph 2.2.5).

<u>4.5. Upland Vegetation and Wildlife.</u> No alternatives would have a significant impact on upland vegetation or wildlife. However, with a long term drawdown of the lake, re-vegetation of the shoreline would occur in the short term. Once lake levels return to historic levels, those re-vegetated areas would become inundated and return to aquatic habitat. Also, if a dam failure or loss of the pool occurred, there could be an adverse impact to upland vegetation and wildlife throughout the floodplain downstream of Wolf Creek Dam.

4.6. Hydroelectric and Fossil Fuel Power Production. The decision to reduce the pool elevation will have a significant negative impact on hydropower production. At Wolf Creek Dam, hydropower depends on the lake elevation being kept above Elevation 673 at which point the lake is still about 130 feet deep. Most hydropower benefits will be foregone by the Wolf Creek power plant. In addition, as Wolf Creek normally supplies up to 69 percent of the downstream water, hydropower production at Cordell Hull, Old Hickory, Cheatham, and Barkley Lakes will also drop if not cease all together. Without the water in storage at Wolf Creek, it would not be possible to meet the weekly minimum energy goals listed in Table 2 above.

If circumstances require an even greater drop in lake levels, the lack of water could jeopardize the ability of the Sherman-Cooper, Gallatin, and Cumberland City fossil fuel plants to produce electricity. Under all action alternatives the risk of the fossil fuel plants having to de-rate or to cease operations would be related to the climatic conditions. Because of the importance of the two fossil fuel plants along the Cumberland River and in order to protect them, Corps Water Management, working closely with water managers and power interests at TVA and the SEPA, would operate the Cumberland River Reservoir System to forego hydropower generation for peaking capability.

Both the impacts to hydropower and to the fossil fuel power plants combined would have a significant impact on the regional power grid and may lead to brownouts or blackouts.

<u>Alternative 1, No Action.</u> The No Action alternative would have no impact on current hydropower or fossil fuel power production. However, during dam repairs, if a dam failure or loss of the pool occurred, many fossil fuel power plants would cease to operate. In particular, John Sherman Cooper, which has a cooling water intake at elevation 675 ft would not be able to operate. Other fossil fuel power plants all along the Cumberland River would have to significantly de-rate (generate less power) or cease operations because water temperatures within the river would be too high to properly cool the plant.

<u>Alternative 2, Maintain Lake Cumberland pool height at 680 ft.</u> This alternative would likely have a severe affect on hydropower during any climatic condition. It permits little to no storage for hydropower releases at Wolf Creek, and greatly reduces the flow of Cumberland River, which affects hydropower production at the other downstream Cumberland River projects. Because of the adverse impacts to water quality under this alternative, many of the Cumberland River projects would be releasing water through the spillway gates in order to increase the amount of DO. Under that scenario, hydropower would not be produced.

During drought conditions, water flows would drop and temperatures would likely rise in the Cumberland River until Gallatin and Cumberland City fossil fuel plants would have to significantly de-rate. During 2007, while Wolf Creek is currently drawn down to 680 ft, Gallatin and Cumberland City have both had to de-rate on multiple occasions.

<u>Alternative 3, Maintain Lake Cumberland pool height at 650 ft.</u> Under this alternative, hydropower production would stop completely at Wolf Creek Dam. At elevation 650 ft,

the water level does not reach the intakes for the hydropower turbines. It is likely that water quality and water flow throughout the Cumberland River would be so adversely affected that hydropower would also stop or be severely impacted at the other projects as well.

Water temperature in the Cumberland River immediately downstream of Wolf Creek Dam would increase under this alternative, more so than with a Lake Cumberland pool elevation of 680 ft. It is possible that fossil fuel plants would have to completely stop operations. John Sherman Cooper plant above Wolf Creek Dam would no longer be able to operate because warmer water temperatures within Lake Cumberland would no longer provide cooling water for their operations. Brownouts and/or blackouts would be a distinct possibility throughout the Cumberland River Valley, maybe further.

Alternative 4, Maintain Lake Cumberland with a partial fill guide curve between 685 and 700 ft. Impacts to hydropower and fossil fuel power that have been discussed above would still be possible under this alternative. However, having a buffer of cold water storage provides operation managers with flexibility to counteract conditions caused by the weather. It is possible that through designed release, managers could keep water temperatures and flows in check in order to lessen the impact on the fossil fuel power plants. Hydropower could likely still be generated at all the Cumberland River Projects, however, peak demands and weekly minimum energy goals would still not likely be met.

Alternative 5, Manage the Cumberland River system in accordance with an Interim Operating Plan. All adverse impacts as described above could occur under this alternative. However, under this interim plan, the system would be operated to minimize all adverse impacts to the greatest extent possible. Also, according to the interim operating plan, the system would be operated according to ordered priorities (see paragraph 2.2.5). An effort would be made at Laurel River Lake to hold higher summer pool elevations (not to exceed elevation 1018 ft) to support operation of the John Sherman Cooper Power Plant. This would require close coordination with SEPA and the East Kentucky Electric Cooperative.

4.7. Flood Risk Management.

Alternative 1, No Action. The No Action alternative would continue to see positive benefits to flood risk management, and the status quo would be maintained. However, during dam repairs, if a dam failure or loss of the pool occurred, Wolf Creek Dam would not be able to provide any flood risk management benefits. The result would be initially a very large flood throughout the Cumberland River Basin downstream of Wolf Creek Dam.

Alternatives 2,3, and 4. The decision to reduce the pool behind Wolf Creek Dam would potentially provide even greater flood storage capacity, at least during the summer pool period. However, while lowering target pools at Wolf Creek would actually increase the flood storage capacity of the system, the operation necessary to consistently maintain lower levels could compromise the flood risk management benefits of the additional storage capacity. Following a significant runoff producing event, priority will be given to

Wolf Creek to evacuate water stored above the target elevation. This presents a couple of issues that have the potential to compromise overall system flood risk management capability. First, if a series of events come in close succession, there is the potential to accumulate water in the downstream projects to a level that impacts system operation. Second, if a follow up event hits the downstream uncontrolled portion of the basin in conjunction with an aggressive release pattern at Wolf Creek to reduce its storage, flood crests could be higher than otherwise experienced. This could occur at any of the Cumberland River damage centers (Celina, Carthage, Nashville, and Clarksville) or along the lower Ohio or Mississippi Rivers.

<u>Alternative 5, Manage the Cumberland River system in accordance with an Interim Operating Plan.</u> Under this interim plan, the system would be operated to minimize all adverse impacts to the greatest extent possible. However, impacts to Flood Control described above could still occur under this alternative.

4.8. Air Quality.

<u>Alternative 1, No Action.</u> The No Action alternative would not have an effect on air quality. However, during dam repairs, if a dam failure or loss of the pool occurred, Lake Cumberland would no longer be able to provide water flow to the Cumberland River Reservoir System. Impacts to hydropower would likely require affected utilities (i.e. TVA) to find replacement power. Fossil Fuel Power would likely be the replacement. Increased production from fossil fuel plants could have a minor negative impact on air quality.

<u>Alternatives 2 and 3.</u> Maintaining Lake Cumberland with a constant target pool elevation leaves little ability to release water in order to generate hydropower. The loss of hydropower supply to utilities such as TVA could require them to seek power from other sources such as fossil fuel power. If fossil fuel power generation is increasd to meet these demands, a minor impact to air quality may occur.

<u>Alternative 4, Maintain Lake Cumberland with a partial fill guide curve between 685 and 700 ft.</u> Alternative 4 provided operation managers the flexibility to release water to maximize project purposes. Hydropower generation would be less impacted than under alternative 2 and 3. Impacts to air quality would likely be insignificant.

<u>Alternative 5, Manage the Cumberland River system in accordance with an Interim Operating Plan.</u> Under this interim plan, the system would be operated to minimize all adverse impacts to the greatest extent possible. However, impacts to air quality described above could still occur under this alternative.

4.9. Wetlands.

<u>Alternative 1, No Action.</u> The no action alternative would see the continuation of normal operations. Therefore, there would be no change to shallow water habitat. However, during dam repairs, if a dam failure or loss of the pool occurred, Lake Cumberland would

be drained to the original Cumberland River channel depth. Thousand of acres of shallow water habitat would be drained. It is likely, however, that many acres of shallow water habitat, mudflats, and riverine wetlands would develop as a result of the lost impoundment.

<u>Alternatives 2,3,4, and 5.</u> A change in normal operations to lower water levels would affect shallow water habitat dramatically. Many acres of shallow water habitat would be drained. However, it is also likely that many acres of shallow water habitat would be created by lowering water levels to expose lower lake bed elevations. The net result would likely be negligible.

<u>4.10. Threatened and Endangered Species.</u> Listed species occur in communities described under Aquatic Resources (Section 3.4) and Upland Habitat and Wildlife (Section 3.5). The impact of each alternative on listed species would be the same as the impacts described for these resources under Sections 4.4 and 4.5. A Biological Assessment was completed, detailing listed species impacts. Impacts are summarized below and are covered in detail in the Biological Assessment in Appendix A.

<u>Alternative 1, No Action.</u> The No Action alternative would have no direct effect on the status quo for Threatened or Endangered Species. However, during dam repairs, if a dam failure or loss of the pool occurred, there would be severe impacts to aquatic and terrestrial habitats. Severe impacts to federally listed species likely would occur.

<u>Alternative 2 and 3.</u> Lowering Lake Cumberland to a single target elevation may affect, but is not likely to adversely affect federally listed species. For pollution intolerant species, it could be damaging. If weather conditions were favorable (normal dry summer) water quality and flows could be maintained as to have minimal effect on water quality under the 680 ft alternative. However, under the 650 ft alternative water quality would likely be adversely affected regardless of the weather patterns.

<u>Alternative 4, Maintain Lake Cumberland with a partial fill guide curve between 685 and 700 ft.</u> This alternative allows for operational flexibility in how much water can be released and when. Increased flows in the summer months would help to maintain DO levels to status quo levels. There would also be more water available for dilution of pollutants. This alternative is unlikely to impact any federally listed species.

<u>Alternative 5, Manage the Cumberland River system in accordance with an Interim Operating Plan.</u> Under this interim plan, the system would be operated to minimize all adverse impacts to the greatest extent possible. This alternative is unlikely to impact any federally listed species.

<u>4.11.   Archaeological, Historical, and Cultural Resources.</u> There are numerous previously recorded archaeological sites within the Corps of Engineers fee title lands at Lake Cumberland. A total of 53 of these sites are located below the Lake's summer pool level (723' AMSL). The majority of these previously recorded sites (n =35) remain underwater. Only two of the 18 previously recorded sites found between the current pool level and the summer pool level are within the elevation range (670' -690' AMSL) that is thought to contain the sites at immediate risk from shoreline erosion. Those remaining sites that are exposed by the lowered pool level also are at risk (but of a lesser nature) from erosion and looting.

The most recent archaeological assessment field survey conducted after the drawdown revealed, however, that the areas around the Lake contain many previously unrecorded archaeological sites. Thirty-one such sites were identified during the survey, a survey that examined approximately 1.1% of the exposed shoreline. A number of these sites appeared to have the potential to be eligible for listing on the National Register of Historic Places, based on the diversity of the collections and the evidence for seemingly intact archaeological deposits. Unfortunately, many of these sites had been impacted by looting of artifacts between the drawdown of the pool level in January 2007 and the April 2007 survey. Clearly, the Lake Cumberland project area is extraordinarily rich in archaeological resources. Prehistoric and historic activities in this area are poorly understood due in large measure to the inundation of the Cumberland River and its proximate drainage system during the 1950s. Many sites reflective of this past activity have been exposed recently by the pool lowering. These sites are now threatened by erosion (both sheet erosion and wave-driven erosion) and by looting.

Section 106 of the National Historic Preservation Act requires Federal agencies to take into account the affect of their activities or undertakings on historic properties and provide the President’s Advisory Council on Historic Preservation an opportunity to comment. Section 106 is implemented by regulations in 36 CFR 800. In light of the emergency nature of the drawdown of Lake Cumberland, project notification was provided to the Advisory Council on Historic Preservation, the Kentucky State Historic Preservation Officer, and to relevant Federally recognized tribes in accordance with regulations at 36 CFR 800.12 covering emergency situations. Consultation with these agencies and the tribes is on-going.

The Nashville District has proposed that adverse effects to historic properties be addressed by stipulations within a Programmatic Agreement (PA) amongst the Corps of Engineers, the Advisory Council on Historic Preservation, and the Kentucky State Historic Preservation Officer; relevant Native American tribes would be invited to concur in the agreement. The agreement would stipulate requirements for additional survey, limited archeological testing to determine National Register eligibility, and data recovery, should that be determined necessary.

<u>Alternative 1, No Action.</u> The No Action alternative would see a continuation of minimal impacts to historic properties. It is the finding of the Corps of Engineers that most, if not all, archeological properties exposed during normal operations of Lake Cumberland between Summer and Winter pools have been severely eroded and deflated to the extent that nearly all contextual information has been lost. However, during dam repairs, if a dam failure or loss of the pool occurred, numerous archeological sites would be exposed and subject to erosion, looting, and other destructive processes.

Alternative 2, Maintain Lake Cumberland pool height at 680 ft. The lowering of the pool elevation to the 680 foot elevation exposed a large number of archeological properties to sheet erosion, wave action, and potential looting. As noted above, an assessment survey of archeological resources in a 1.1% sample of newly exposed shoreline resulted in the identification of thirty-one (31) archeological sites. Several of these contain relatively intact archeological deposits and are considered potentially eligible for listing on the National Register of Historic Places. Extrapolating from current survey results to the lake as a whole, it is very likely that several hundred archeological sites have been exposed to adverse impacts as a result of the drawdown, many of which may be eligible for listing on the National Register of Historic Places.

Alternative 3, Maintain Lake Cumberland pool height at 650 ft. Lowering of the pool to the 650 foot elevation would result in the exposure of many more archeological sites to the destructive impacts of erosion, wave action at and below the shoreline, and create a situation very conducive to extensive illegal collection and looting of artifacts.

Alternative 4, Maintain Lake Cumberland with a partial fill guide curve between 685 and 700 ft. Maintaining the pool at any elevation below 690 feet has the potential to adversely affect historic properties, particularly archeological sites.

Alternative 5, Manage the Cumberland River system in accordance with an Interim Operating Plan. Under this interim plan, the system would be operated to minimize all adverse impacts to the greatest extent possible, regardless of what pool elevation was being maintained; however, adverse impacts to historic properties would only be indirectly considered within the established river system regulation priorities. Under this alternative all impacts described above could still occur.

4.12. Noise. Neither the No Action alternative nor the decision to lower the pool would have an effect on noise.

4.13. Recreation. The decision to lower the pool level, however, will have many negative effects on recreation.

As the cold water fisheries are decimated fishing will decline both on the lake and in the tailwater. With lack of access and poorer fishing, other related recreational pursuits such as camping and picnicking will also decline.

Alternative 1, No Action. The No Action alternative would see a continuation of the valued recreational benefits both in the lake and in the tailwater. However, during dam repairs, if a dam failure or loss of the pool occurred, nearly all recreational opportunities would be lost.

Alternative 2, Maintain Lake Cumberland pool height at 680 ft. With Lake Cumberland drawn down elevation 680 ft, recreation is severely affected. In 2007, recreational visits have been lower than in previous years (see table 4 for visitation numbers). Figure 6 shows a graph of 2005, 2006, and 2007 visitation data. Public controversy relating to the drawdown has and would cause many visitors to stay away from the Lake Cumberland area. The Corps' Natural Resources Staff estimated that there could be at least a 50% decline in visitation by reducing the pool elevation. Many recreational facilities become unusable at this elevation. When the lake was drawn down to elevation 680 ft, an extensive number of boat launching ramps were adversely impacted. There were 7 ramps out of 48 that were unusable. Only 7 launching lanes were available of the original 83. There have been many lanes at 17 separate ramps that have been extended. Currently there are 37 lanes available. Other lanes could be extended in the future. At least two of the eleven marinas have had to reconfigure their slips. Alligator 1 and Buck Creek have requested to relocate their marinas to entirely new locations. Many private boat docks are adversely impacted.

Lake Cumberland has a large number of submerged islands. With the lake level drawn down, boaters would not always be able to navigate to areas that they are accustomed to. At elevation 680 ft, the lake's surface area is reduced by over 12,000 acres, to 37, 680 acres. Because of a crowding effect, there could be an increase in the risk and numbers of boating related accidents.

Depending on the weather, the lake and tailwater cold fishery could be impacted dramatically. If temperatures rose high enough and DO dropped low enough, there could be high numbers of fish kills. Fishing might be impacted for up to 15 years in the lake.

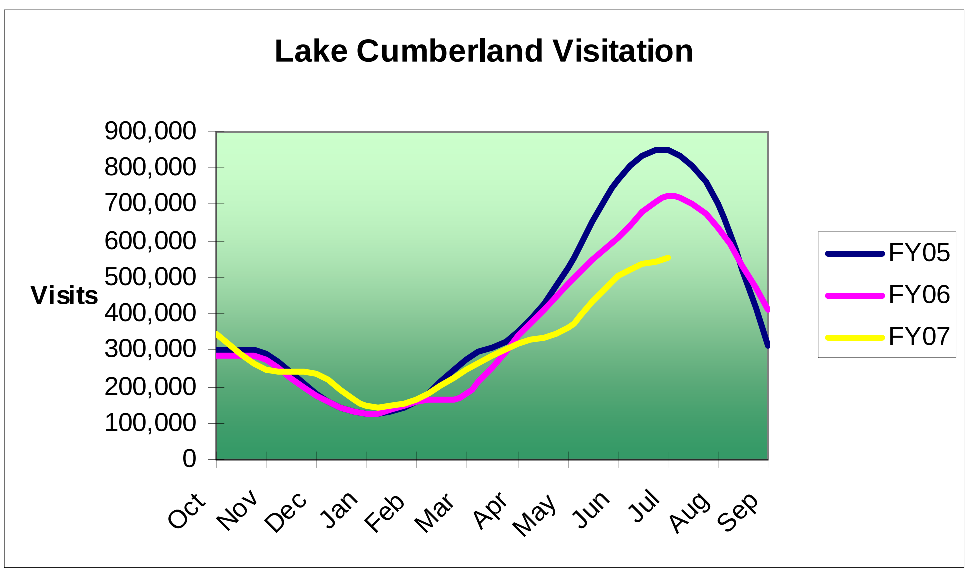


Figure 6. Lake Cumberland visitation since 2005

Alternative 3, Maintain Lake Cumberland pool height at 650 ft. If the lake were drawn down to elevation 650, it is feasible that nearly all recreation on Lake Cumberland would cease. All launching ramps would be unusable. Most marinas would shut down due to lack of water depth. It's likely that the tailwater and lake cold water fisheries would be completely lost. Depending upon the water quality effects along the Cumberland River, fishing along the entire Cumberland River could also be severely impacted. High temperatures and low DO through out the river basin could cause wide-spread fish kills all the way down to Old Hickory dam and possibly lower. At elevation 650 ft, the lake's surface area is further reduced by over 20,000 acres, to 29,380 acres. If boat launching ramps were extended and boaters were able to launch, a crowding effect as described in alternative 2, would likely be worse.

Alternative 4, Maintain Lake Cumberland with a partial fill guide curve between 685 and 700 ft. At elevation 700, Lake Cumberland's surface area is reduced to 46,240 acres, from 50,250 acres at elevation 723 ft. It is further reduced to 39,040 acres at elevation 685. If the lake were returned to this higher level from 680 ft, publicity could raise visitation from where it has declined in 2007. Crowding, as described under Alternative 2 and 3 could possibly be more likely, due to an increased number of boaters.

Alternative 5, Manage the Cumberland River system in accordance with an Interim Operating Plan. Under this alternative all impacts described above could still occur. Under this plan, the lake level at Laurel River Lake could be held higher in the summer without significantly impacting other project purposes there. That operation would have an added benefit of supporting lake based recreation. Water control actions implemented for water supply and water quality requirements will have the added benefit of supporting fish and aquatic life based recreational pursuits. Minimum daily project releases would continue to be made where they are required under the existing operating criteria. The relatively low summer and fall releases from Wolf Creek would enhance wade fishing opportunities in the tailwater.

4.14. Economics. Wolf Creek Dam and Lake Cumberland constitute a significant economic engine for the region.

Alternative 1, No Action. The No Action alternative would see a continuation of the benefits this project provides. However, during dam repairs, if a dam failure or loss of the pool occurred, there would be severe economic losses. All recreation would likely cease, drawing visitation and tourism to the local area to near nothing. All benefits from recreation (approx. 4150 million) to the region would stop. Damages from flooding incurred downstream of Wolf Creek Dam would exceed $3.6 billion.

Alternatives 2,3,4, and 5. The decision to lower the lake will have a significant economic impact on the region due to the severe impacts of almost all of the authorized project purposes. The KDFWR has estimated that lowering the pool to 680 ft will result in the loss of most of the cold water fisheries both in the lake and the tailwater. There would also be a corresponding loss of revenue from a decline in fishing license purchase. The Commonwealth of Kentucky would also lose federal money based on the loss of license sales although the exact value is not clear. After the lake is restored it would take approximately 15 years to fully restore the fishery.

Relatively inexpensive and dependable electricity provided by hydropower generation and the fossil fuel power plants along the Cumberland River has contributed to the region's economic well-being. The decision to lower the pool will severely impact most those benefits. This will also result in lost revenues to the Federal government and increased power costs to the consumers. If Impacts to Fossil Fuel plants described in paragraph 4.6 above were to occur, there would be a significant increase in the expense for power for the region of Lake Cumberland all the way down the Cumberland River Basin. As an example, TVA estimates that if Cumberland City Power Plant had to be taken off line, it would cost them about $1 million per day.

A number of other, less well defined economic losses will occur as well. These include increased water treatment costs for municipal water intakes, disruption of businesses and communities, possible impacts to navigation, and a generally depressed regional economy. Capturing the full economic impact of this decision is beyond the scope of this study.

<u>Alternative 2, Maintain Lake Cumberland pool height at 680 ft.</u> There could be a reduction in visitation of up to 50%. This translates into an estimated loss of $75 million dollars annually to the local economy surrounding Lake Cumberland. Business owners would lose a high amount of income and many might have to close. Flood risk management translates to an annual prevention of 33.1 million in potential flood damages. Flood risk management would continue and flood storage capability at Lake Cumberland actually increases with a lower pool. However, because of operations necessary to consistently maintain a lower pool elevation, flood risk management benefits of additional flood storage could be irrelevant.

<u>Alternative 3, Maintain Lake Cumberland pool height at 650 ft.</u> If Lake Cumberland were lowered to elevation 650 ft, there would likely be a total loss of economic benefits. Launching ramps would be totally disabled, all 11 marinas would likely shut down, and visitation/tourism would plummet to near zero numbers. That would translate to an approximate total annual loss of $150 million to the regional economy. Many business owners could go bankrupt. There would be a high percentage of job loss which could lead to a mass of people moving from the region.

<u>Alternative 4, Maintain Lake Cumberland with a partial fill guide curve between 685 and 700 ft.</u> If the current pool at Wolf Creek, which is at elevation 680 ft, the declined visitation numbers of FY 2007 would likely return to more historical levels. However, due to the potential water quality impacts under this alternative, there still could be a potential decline in the coldwater fisheries in the lake and tailwater. This could still lead to declines in visitation and fishing license sales. Flood risk management benefits (33.1 million annual in flood damage prevention) could still be compromised by the operations required to maintain lower elevations. None of the economic impacts would likely be as severe under this alternative as they would be under other action alternatives.

<u>Alternative 5, Manage the Cumberland River system in accordance with an Interim Operating Plan.</u> Under this interim plan, the system would be operated to minimize all adverse impacts to the greatest extent possible, regardless of what pool elevation was being maintained. However, all economic impacts described above could still occur.

4.15. Erosion.

Alternative 1, No Action. The No Action alternative would not have an effect on erosion rates. However, during dam repairs, if a dam failure or loss of the pool occurred, there would be an initial, severe erosion of the shorelines in Lake Cumberland and all along the Cumberland River. Sedimentation impacts to the river bed would likely be severe. However, natural stabilization would be relatively quick.

Alternative 2, Maintain Lake Cumberland pool height at 680 ft. A temporary increase in erosion of the shoreline at Lake Cumberland has occurred. However, with the lake level relatively stable at elevation 680 ft, vegetation has quickly begun to regenerate, stabilizing the eroding soils. If the pool is continually maintained, further stabilization will take place as vegetation continues to grow.

Alternative 3, Maintain Lake Cumberland pool height at 650 ft. Under this alternative, there would likely be a high amount of erosion to the shorelines both in Lake Cumberland and all along the Cumberland River. Maintaining a constant pool elevation of 650 ft would be very difficult and high rates of fluctuation would be likely. It would be difficult for vegetation to establish because of frequent wetting and drying. Below Wolf Creek Dam, there would be frequent periods of high flow rates.

Alternative 4, Maintain Lake Cumberland with a partial fill guide curve between 685 and 700 ft. Erosion rates experienced under this alternative would likely be close to what they have been in the past under normal operations. Under this alternative the pool elevation would fluctuate between elevation 685 and 700 ft. Therefore, vegetation would likely not establish on the shoreline in that elevation range. However, the rate of erosion could be somewhat lower than in the past, because under normal operations, there is a 33 foot range of elevation fluctuation. Under a fifteen foot elevation, there would be less of an area that is not stabilized by vegetation.

Alternative 5, Manage the Cumberland River system in accordance with an Interim Operating Plan. Under this interim plan, the system would be operated to minimize all adverse impacts to the greatest extent possible, regardless of what pool elevation was being maintained. However, all rates of erosion described under the other action alternatives, could still occur.

4.16. Aesthetics.

Alternative 1, No Action. The No Action alternative would not have an effect on aesthetics. However, during dam repairs, if a dam failure or loss of the pool occurred, there would be severe impacts to aesthetics. High amounts of damage would occur to all aesthetic aspects of the human environment throughout the Cumberland River Basin.

Alternatives 2,3,4, and 5. While aesthetics are purely subjective, most people will view the decision to drawdown the lake to be aesthetically unappealing. Drawing the lake down will reveal additional cliffs and present a dramatic range of natural features.

4.17. Environmental Justice. Any effects resulting from operational changes at Wolf Creek Dam would affect all human populations equally. In addition public meetings were conducted to equally inform the public about the interim pool elevation alternatives. As a result, the requirements of this executive order have been met. The analysis concludes that for all alternatives, there were no disproportionate effects on minority or low-income populations.

4.18. Navigation. A nine-foot commercial navigation channel on the Cumberland River is generally supported by the maintenance of full, flat pools and minimum tailwater elevations at the four main-stem projects. There are navigation impediments in the approaches to both Old Hickory and Cheatham that can affect navigation during low flow conditions. Tows are dependent on favorable release schedules to transit reaches below the navigation projects. Although navigation is not an authorized project purpose, releases from Wolf Creek contribute to the overall available flows.

Alternative 1, No Action. The No Action alternative would not have an effect on navigation. However, during dam repairs, if a dam failure or loss of the pool occurred, there would be sever impacts to navigation, particularly during and for sometime after an initial loss of pool.

Alternatives 2,3,4, and 5. If the pool is lowered in Lake Cumberland, there would be less water available for releases during drier months. While Wolf Creek does not release flows specifically for navigation, without the flows normally provided for other project purposes during the drier months and without the ability of other projects to compensate, navigation could be impacted. Adverse impacts could include lessening the amount of time available for barge traffic to maneuver approaches to Old Hickory and Cheatham Locks.

4.19. Hazardous, Toxic, or Radiological Waste. None of the alternatives under consideration would have an effect on hazardous, toxic, or radiological wastes.

4.20. Traffic. No alternative would result in changes to traffic patterns except Alternative 1, No Action. During dam repairs, a dam failure would result in closure of Highway 127 crossing the dam. Traffic would have to detour around Lake Cumberland which would increase travel distance by at least 100 miles.

4.21. Safety. One of the authorization purposes for constructing Wolf Creek Dam was to reduce the loss of lives and property from downstream flooding. An important consideration regarding safety is to determine if the reduction in hydrostatic pressure to reduce the risk of dam failure or loss of the pool outweighs the ecological and economic impacts that would occur by lowering the lake. The impact on safety is described below.

Alternative 1, No Action. Under this alternative, the high risk of dam failure virtually eliminates any safety from downstream flood or upstream and downstream drought. Under Alternative 1, dam failure or loss of the pool would result in severe repercussions (EPA, 2007.) including: 1.) loss of life from surging flows, 2.) destruction of property, 3.)

harm to the downstream river environment, 4.) risks of life threatening hazards to river users, and 5.) loss of delivery of critical services to communities with the loss of power generation, roads, bridges, and other infrastructure.

Alternative 2, Maintain Lake Cumberland pool height at 680 ft. This alternative is about 43 feet below normal summer pool and 15 feet below normal winter pool. This alternative dramatically reduces risk and increases dam safety. The pool could hold a significant storm event with little increase in risk.

Alternative 3, Maintain Lake Cumberland pool height at 650 ft. This alternative would practically eliminate risk and ensure dam safety. The pool could hold a significant storm event with little increase in risk. This elevation would eliminate potable water supplies in Lake Cumberland and any fire fighting ability to upstream and downstream users unless water intakes were extended to lower lake elevations.

Alternative 4, Maintain Lake Cumberland with a partial fill guide curve between 685 and 700 ft. This alternative is about 23 feet below normal summer pool and 10 feet below normal winter pool. This alternative reduces the risk of dam failure and increases safety. A significant storm event could raise the pool several feet, but the initial low pool would maintain low hydrostatic pressure. During drought, this elevation ensures a water supply for fire fighting to upstream and downstream uses.

Alternative 5, Manage the Cumberland River system in accordance with an Interim Operating Plan. Under this interim plan, the system would be operated to minimize all adverse impacts to the greatest extent possible, regardless of what pool elevation was being maintained. However, all safety levels described under the other action alternatives, could still apply.

4.22. Cumulative Impacts. Cumulative impacts are defined as "the impact on the environment which results from the incremental impact of the (proposed) action when added to other past, present, and reasonably foreseeable future actions regardless of what agency or person undertakes such other actions (40 CFR 1508.7)". Council for Environmental Quality (CEQ) guidance identifies an 11-step process for evaluating cumulative effects. For the purposes of cumulative effects, the spatial boundary generally includes Lake Cumberland/Wolf Creek Dam at CRM 460.9 (including all backwater/embayment areas within the reservoir) and the Cumberland River 430.2 miles downstream to Barkley Dam at Cumberland River mile 30.7. The temporal boundary covers the past 55 years, after impoundment of Lake Cumberland, and 7 years into the future, on completion of dam repairs. These boundaries were selected because they cover the entire Wolf Creek Dam project and its impact to the Cumberland River System. As discussed below, both are adjusted as appropriate for each resource. Past, present, and foreseeable actions that could combine for cumulative effects include, dam safety considerations, weather, human population growth, and land and water developments.

The assessment can be defined as "what resource goals is the proposed action going to affect". Effects can result from either direct-project related, indirect-project related, and independent indirect causes. Based on public and agency scoping and review of previous NEPA documents, the following resources have been identified as target resources within the assessment goals: 1.) Hydrology and the Cumberland River Reservoir System, 2.) Hydropower, 3.) water supply, 4.) water quality, 5.) aquatic resources including threatened and endangered fish and freshwater mussel species, 6.) socioeconomics, 7.) recreation/tourism, 8.) river navigation.

Hydrology and the Cumberland River Reservoir System. For the purposes of cumulative effects, the spatial boundary includes Lake Cumberland/Wolf Creek Dam at CRM 460.9 (including all backwater/embayment areas within the reservoir) and the Cumberland River 430.2 miles downstream to Barkley Dam at CRM 30.7. Demands for this resource include withdrawals for municipal and industrial purposes, hydropower generation, water quality, aquatic resources including threatened and endangered fish and freshwater mussels, recreation, and to a lesser degree, maintaining commercial navigation. Weather conditions, such as drought or storm events, also affect water quantity. Cold water within the reservoir is particularly in demand because it retains more DO, supports a cold water fishery, and is necessary to maintain water quality for downstream thermal plants. During wet years, warm inflows can raise lake temperatures and dilute the available cold water stored in the hypolimnion. During dry years, the quantity of cold water is finite. Lowering Lake Cumberland reduces the amount of cold water and retention time. Historically, under normal operations, there has been sufficient cold water to meet demands. Lowering the lake level is likely to result in insufficient storage of cold water. Lack of cold water would result in decreased water quality, negative impacts to aquatic resources, including threatened and endangered species, decline in recreation, lack of water for hydropower generation, insufficient cold water to supply cooling needs of the thermal plants, and could limit navigation downstream. If Wolf Creek was the only reservoir affected then the other nine reservoirs of the Cumberland River system could likely meet most of the needs. However, when more than one storage reservoir is affected by lower lake levels, then there would not be enough water to meet the demands of all users. Potential impacts could include rolling black-outs due to insufficient thermal power generation, grounded barges, fish kills, and damage to the regional economy. Loss of power, even temporary, could have detrimental effects on human health. Potable water systems could loose pressure forcing a boil-water advisory. Sewage treatment plants would malfunction, resulting in discharge of untreated waste water into rivers and lakes. Transportation effects would include highway traffic gridlock, and shutting down gas stations, railways and airports. The loss of power would affect hospitals, fire stations, schools, stores, and industry. Cellular communication services could be disrupted. This situation could jeopardize public safety and welfare. Mitigation measures might include a prioritization of water uses. A drought contingency plan has already been developed to cover such exigencies. Water quantity would be constantly monitored and the situation would be continuously reassessed. On successful completion of dam repairs, Wolf Creek Dam would return to the status quo condition of supporting all project purposes including its normal flow contribution to the Cumberland River Reservoir system. The cumulative effect of the successful completion of repairs, to both Wolf Creek and Center Hill Dams would return the Cumberland River system to pre-repair condition.

Hydropower. For the purposes of cumulative effects, the spatial boundary coincides with the SEPA power grid. Demands for this resource include peaking power at Wolf Creek Dam and its contribution to the power grid. Demands for the water used for hydropower include water for minimum flow, water quality, fish and wildlife management, and recreation. Under minimum flow releases, hydropower generation adds little oxygen to improve downstream water quality to support the cold water fishery. Instead, water for hydropower is diverted through a sluice gate to meet both minimum flow and water quality needs. Lowering the lake reduces the amount of water available for hydropower. When lake levels reach EL 676 ft, no hydropower can be generated. Historically, under normal operations, the high summer lake level easily provided sufficient hydraulic pressure for hydropower peaking needs and excess power could be sold on the power grid. During the winter pool, winter and spring rainfalls were captured and stored and released by hydropower generation to produce excess and cheap electricity to the grid. Lowering the lake would reduce hydropower generation, and at a low enough pool, eliminate hydropower generation. Under this condition, power would have to be bought from another source to supply electrical power to the grid which is likely to raise costs to the local utilities and ultimately, their customers. The higher cost of electricity could force local businesses to reduce production and cut jobs, which would impact the local economy. If Wolf Creek was the only reservoir affected by low lake levels, the other nine dams could possibly meet the hydropower needs, however, when more than one dam is affected, more electricity has to be bought to supply the power grid. Also, because of the lack of water releases due to drought conditions, water quality is reduced and other dams along the Cumberland River have been forced to release water through their spillway gates. This also significantly reduces generation throughout the Cumberland River. The cumulative effect of the high cost of electricity on a regional scale would likely reduce business production, cut jobs, and negatively impact the regional economy. When dam repairs are complete, hydropower generation would be expected to return to status quo condition at Wolf Creek Dam and its contribution to the power grid.

Water Supply. For the purposes of cumulative effects, the spatial boundary is located at Lake Cumberland (including all backwater/embayment areas within the reservoir), and the tailwater, downstream to Barkley Dam at Cumberland River mile 30.7. There are multiple water supply intakes on Lake Cumberland and all but two are currently located within the power pool (above 673 ft). Other demands for water include hydropower, water quality, aquatic resources, and minimum flow in the tailwater. Under normal operations, there has been abundant water of good quality to fully meet water supply demands. Low lake levels would provide only a few feet of water coverage over the intakes in Center Hill Lake, and the potential to create a vortex to the surface which would pull air and trash into the system. Algae and low flows may cause higher water treatment costs to control taste and odor problems in drinking water supplies, not only in Center Hill Lake, but throughout the entire downstream length of the Cumberland River. Water utilities may need to enforce water restrictions. As population increases over the next 7 years, demands for water supply will rise. Center Hill Dam is currently undergoing repairs and can not contribute water to the Cumberland River system to meet water demands. It is unlikely that Dale Hollow would be able to make-up for the lack of water to meet all the demands. It is increasingly likely that water rationing could be imposed over the entire Cumberland River system, especially during drought conditions. A mitigation measure for water supplies drawn from Lake Cumberland would be to lower water intakes deeper into the pool. Some water users have begun this process. Mitigation measures might include a prioritization of water uses. A drought contingency plan has already been developed to cover such exigencies. Water supply would take priority over all other purposes to protect human life and welfare. Water supplies would be constantly monitored and the situation would be continuously reassessed. On completion of dam repairs at both Wolf Creek and Center Hill Dams, water can be stored to meet current and projected water supply demands.

Water Quality. For the purposes of cumulative effects, the spatial boundary is located at Lake Cumberland (including all backwater/embayment areas within the reservoir) downstream to Barkley Dam (CRM 30.7). Demands for this resource includes, aquatic resources including threatened and endangered fish and freshwater mussels, water supply, and recreation. Weather conditions, such as drought or storm events, also affect water quality. Water temperature is addressed above under "Water Quantity. While water temperature affects the type of aquatic community present (cold, cool, or warm water fisheries) all aquatic life requires adequate DO. DO is the second key component of water quality that is considered under this section. Historically, DO in Lake Cumberland and in the tailwater below the Wolf Creek Dam, was sufficient to maintain fish and freshwater mussels. Lower lake levels could change the water quality in Lake Cumberland and in the tailwater. DO and appropriate water temperature is critical in maintaining the health of aquatic organisms, including threatened and endangered species. For warm water species, a DO of 5 mg /l is required for the lake fishery. The tailwater trout fishery below the dam requires a DO of 6 mg/l to maintain healthy populations. Cumulative impacts on DO could occur in several ways. Lake Cumberland water quality is affected by watershed development, point and non-point sources of pollution that enter the lake resulting in added nutrients and biological oxygen demand that can seriously reduce oxygen in the lake to the point of producing fish and mussel kills. The tailwater draws cold water from the bottom of the lake. As a result of the lost oxygen in the lake, the tailwater at times contains little or no oxygen. Operational and structural changes at the dam are needed to improve water quality and replace oxygen in the tailwater by opening a sluice gate. Without these engineered and operational changes, the Wolf Creek tailwater would remain deficient of oxygen during critical summer months. Lower lake levels could result in drawing warmer water from the lake, which holds less oxygen, therefore oxygen added at the dam, may dissipate by the time it reaches the Cumberland River. The combined lower lake levels in both Wolf Creek and Center Hill dams can have a cumulative effect that could result in decreased water quality and development of anoxic conditions down the entire Cumberland River. Under drought conditions, the potential for cumulative anoxic conditions increases in the Cumberland River for a limited time, during late July through October as a result of longer retention times as compared to historical flow regimes. Mitigation measures at Wolf Creek include maintaining a minimum flow and to continue to sluice whenever possible. Add these measures in addition to spilling at the mainstem dams and the cumulative effect may reduce low DO effects. In the next 7 years, human development around Lake Cumberland, as well as along the Cumberland River, is likely to increase, resulting in additional point and non-point sources of pollution. Ensuring point sources meet their discharge requirements, and preventing non-point sources from entering the waterways would do much to preserve the water quality of Lake Cumberland and downstream the Cumberland River.

Aquatic Resources, Including Threatened and Endangered Fish and Freshwater Mussels. Since its impoundment about 55 years ago, Lake Cumberland has significantly altered the hydrology and water quality both of the lake and to areas as far downstream as the Ohio River. The geographic scope of this section, therefore, is all of Lake Cumberland (including all backwater/embayment areas within the reservoir) and all of the Cumberland River downstream to the Ohio River. The temporal boundaries are from the impoundment of Lake Cumberland in 1953 when all of the changes to the waterway became permanent, to fifty years in the future. Because of the size and depth of the lake, after impoundment, water regime in the tailwater downstream of Wolf Creek Dam quickly became a cold water system. The native warm water species have been largely displaced by cold water species including trout which are stocked in the tailwater on a put-and-take basis. The exceptions were mussels which were unable to move and due to the cold water were unable to reproduce. In the tailwater, these have largely died out, although, a few relics may yet remain. Because of the year round low water temperatures below Wolf Creek Dam, this portion of the Cumberland River (approximately 70 miles) has been classified as a cold water stream. Impoundment of the other dams, downstream of Wolf Creek, extirpated many species throughout much of their reaches. The exception is in the downstream areas of certain dams which are similar in habitat to the original river. In addition to the cold water, the greatest stress on these animals is water quality, or the lack thereof. As Lake Cumberland and Center Hill are drawn down during repairs, there will be less flow in the rivers during the summers. A warmer water regime would return, but would likely be accompanied by poorer water quality. As water temperatures increase, so too would algal blooms. As the algae dies, the DO could be reduced to near zero. As the Cumberland River Basin's population increases and more and more of the areas around the reservoirs are developed, it is expected that future nutrient loading, which supports algal growth, will increase and DO in the tailwaters will decrease. The cool water and the native warm water ecosystem could then see fish kills and major die-offs of the macroinvertebrate community. Seven species of Federal threatened or endangered species have been identified as "may affect, but not likely to adversely affect". Several methods of mitigation discussed elsewhere in this document have been suggested to mitigate the situation. After the repairs have been effected the dams would be returned to full service and conditions such as reverting to a cold water regime would again be in place for the foreseeable future. Under this scenario, it would likely take years for the fishery to fully recover.

Recreation/Tourism. For the purposes of cumulative effects, the spatial boundary is Lake Cumberland (including all backwater/embayment areas within the reservoir) and the downstream tailwater (70 miles). Demands on this resource include, water supply, water quantity, water quality, and aquatic resources including threatened and endangered species. Under normal operations, customary summer and higher winter pool (above 695 ft) can be easily maintained. Though some boating occurs in the winter, recreation activities (boating, camping, and swimming) predominantly occur during the warm summer months, creating a recreational season. Therefore, recreation is most impacted when lake levels are lowered during the summer pool. These recreation users have an economic impact on the local and regional economy. Lower lake levels affect access to the lake, marina operations, and safe boating and fishing. Swimming beaches, boat ramps, boat slips, and some private docks are unusable. Lost access to the lake reduces recreational use which impacts income generated at the lake and the local economy. A loss of approximately $150 million dollars annually could be seen under this condition. During the 7 year dam repairs, maintaining very low lake elevations could result in several hundred millions of dollars of lost revenue. Combine a low lake pool with drought conditions, possible critical hydropower releases, continued water supply withdrawals, and minimum flow requirements for water quality, the lake could remain or even fall lower for an extended period of time even throughout the summer months resulting in economic hardship for the local economy. The cumulative effect of low lake conditions at both Wolf Creek and Center Hill Dams could result in economic hardship for the regional economy. Dale Hollow Lake may also be lowered as it attempts to supply water to the Cumberland River system. Though the effects would be temporary, possibly occurring through the entire dam repair period, it could take years to recoup the financial losses. Mitigation efforts include extending boat ramps, both in the lake and below the dam, re-configuring boat slips, relocating marinas into deeper water around the lake. Over the next 7 years, recreational demands and development pressures will increase. Land around the lakes is expected to become increasingly urbanized. There will be increasing pressure for more water related recreation. Other lake resources such as Dale Hollow and Cordell Hull could experience an increase in visitation, therefore, placing more pressure on natural resources. Balancing the needs of recreation with other project uses will become a challenge. Water resources must be managed in the interest of public health as constant pressure tips the balance toward other interests of the growing population: more water control for water supply, water quality, hydropower, and navigation, in addition to more access for outdoor recreation. On completion of Wolf Creek Dam repairs (7 years) routine operations would be restored along with a customary summer and winter pool elevations. Completion of Center Hill Dam repairs (7-10 years) and maintaining the storage pool at Dale Hollow Dam would have the cumulative effect of restoring the status quo of recreation throughout the region.

Navigation. The geographic scope of this section is from Cordell Hull Dam on the Cumberland River downstream to the Ohio River. The temporal period begins in the 1950s when the Cumberland River mainstem lock and dams were constructed and ranges out to about fifty years in the future. A nine-foot commercial navigation channel on the Cumberland River upstream of Barkley Dam is generally supported by the maintenance of full, flat pools and minimum tailwater elevations at the four main-stem dams (Barkley, Cheatham, Old Hickory, and Cordell Hull). Several factors affect navigation including regional economics and ease of passage. Navigation is not a project purpose at Lake Cumberland. Under normal operations, tailwater releases provide incidental benefits to flow in the Cumberland River. During periods of low flows, navigation of fully loaded barges can become problematic, particularly as the barges enter the tailwater areas below the locks as these are normally some of the shallowest areas of the river. Water releases from the upstream tributary lakes are usually sufficient to keep the navigable reservoir levels above the inactive pools in the mainstem. However, as Wolf Creek and Center Hill undergo repairs, the lack of stored water which is usually released during the summer for hydropower and other project functions may be lacking. Without these customary flows navigation may become difficult. In the past this has resulted in limiting passage to certain windows of opportunity, i.e., releases are scheduled for predetermined times. As water flow drops these windows become shorter in duration and farther apart. Some companies "light load" their barges so that they draft less water and can still pass the shallow areas. Sometimes cargo is diverted to other means of transportation such as trains or trucks. This is usually more expensive, but by saving time may become more economical for some products. Once alternative forms of transportation are found, it can be hard for shippers to reclaim their business. It is assumed that after repairs to the dam are effected in seven years, normal operations would resume for the foreseeable future.

Socioeconomics. For the purposes of cumulative effects, the spatial boundary is centered on Lake Cumberland (including all backwater/embayment areas within the reservoir) downstream to the confluence of the Ohio River, but is actually regional in effect and not limited to the river itself. The temporal boundary covers the past 55 years, after impoundment of Lake Cumberland, to a number of years into the future, when economic recovery can be achieved. Factors influencing socioeconomics include recreation, hydropower, water quantity, water quality, water supply, navigation, aquatic resources, including and property values. Socioeconomic activities include employment, personal income, tax base, local and regional spending on, and the cost of, goods and services. Historically Lake Cumberland has had an increasingly positive impact on local socioeconomics; however, lowering the lake is expected to have the opposite effect. A lower lake would negatively impact recreation, a large generator of local revenue and employment. Many jobs would be lost as fewer people visit the lake. Reduced visits would reduce the number of jobs supporting tourism, as there would be less spending on lodging, eating, fuel, boats, boating, fishing, camping and swimming equipment. Lowering the lake would increase the cost of electricity, as hydropower generation is reduced or eliminated, and the quantity of cold water for fossil fuel power plants is reduced. A lower lake with reduced DO would impact tailwater water quality with the possible elimination of the profitable trout fishery, and potential harm to other aquatic life. Under these conditions, water treatment costs are likely to increase. A depressed local economy may reduce land values and property sales. This economic situation could continue through the 7 years of dam repairs, but could take many years after that to recover. Other factors, such as drought and the repairs at Center Hill Dam, could compound the situation. The cumulative effect of the reduced water quantity in the Cumberland River system would affect navigation, resulting in delivery delays, lighter loading, and re-configuration of barges, resulting in lost revenue. In addition to mitigation measures previously mentioned, public relations might be used to monitor the situation and keep the public current of the actual local conditions.

Historic Properties. For the purposes of cumulative effects, the spatial boundary is Lake Cumberland (including all backwater/embayment areas within the reservoir) and more specifically the areas exposed by drawdown of the reservoir below the normal winter pool elevation of 690 feet. The temporal boundary covers the past 55 years, after impoundment of Lake Cumberland, to a future point in time when the lake can be maintained at and above the normal winter pool elevation. A recently conducted archeological reconnaissance and assessment survey of selected areas within the drawdown area (between elevations 680 and 690 feet) comprising a 1.1% sample of the newly exposed shoreline resulted in the identification of 39 archeological resources, including 31 new sites and 8 previously recorded sites. Site types from newly discovered and revisited sites include late 19th and early 20th century farmsteads and/or residences, and prehistoric lithic scatters representing Early Archaic through Woodland Period occupations. Eleven of these archeological sites are considered potentially eligible for listing on the National Register of Historic Places. Despite having been inundated and exposed to erosion these sites appear to have some degree of depositional integrity and therefore could contain cultural features and/or artifact distribution patterns useful for understanding upland and riverine site occupation and settlement in the Cumberland River region. Maintaining the Lake Cumberland pool at lowered pool elevations (below 690' of elevation) has the potential to impact several hundred additional archeological sites that have yet to be documented by archeologists. These properties will be adversely affected by continued exposure to erosion, wave action, and extensive collecting and looting. Once these resources disappear, through erosion or looting, they are gone forever and part of our history is irrevocably lost.

5.0. List of Preparers.

Chip Hall - Principle Author of EIS
Position: Biologist, Project Planning Branch, U.S. Army Corps of Engineers
Education: B.S., Wildlife and Fisheries Science
Experience: 7 years Biologist, Project Planning Branch

Wayne Easterling – Preparation of Biological Assessment
Position: Biologist, Project Planning Branch, U.S. Army Corps of Engineers
Education: B.S., Biology
Experience: 18 years Park Ranger
3 years Project Manager
7 years Biologist, Project Planning Branch

Patty Coffey – Environmental Team Leader and Technical Review
Position: Biologist, Project Planning Branch, U.S. Army Corps of Engineers
Education: M.S., Biology
Experience: 2 years Park Ranger
20 years Biologist, Project Planning Branch
3 years Outdoor Recreation Planner

Ray Hedrick – Independent Technical Review
Position: Ecologist, Project Planning Branch, U.S. Army Corps of Engineers
Education: B.S., Wildlife Biology
Experience: 3 years Park Ranger
28 years Ecologist, Project Planning Branch

Robert Karwedsky – Author, Cultural and Historic Resources
Position: District Archaeologist, U.S. Army Corps of Engineers
Education: M.S., Anthropology
Experience: 26 years Archaeologist

6.0. List of Agencies, Organizations, and Persons to Whom Copies the Scoping Letter was Sent.

State Historic Preservation Office Frankfort, Kentucky	Lee Andrews, USFWS Frankfort, Kentucky
Department of Natural Resources & Environmental Protection Cabinet Frankfort, Kentucky	Department of Environment Protection Attn: Alex Barber Frankfort, Kentucky
Kentucky State Clearinghouse Department of Local Government Frankfort, Kentucky	Gerald Miller US EPA, Office of Env. Assessment Atlanta, Georgia
Governor's Office of Agricultural Policy Frankfurt, Kentucky	Division for Air Quality 803 Schenkel Lane Frankfort, KY 40601
Kentucky Department of Agriculture Capitol Annex, Room 188 Frankfort, Kentucky 40601	Division of Conservation 663 Teton Trail Frankfort, KY 40601
Cabinet for Health Services 275 East Main Street Frankfort, KY 40621	Kentucky Department for Environmental Protection Frankfort, KY
Kentucky Department for Natural Resources Frankfort, KY	Dept for Surface Mining Reclamation & Enforcement. Frankfort, KY
Kentucky Transportation Cabinet Frankfort, KY	Kentucky Division of Environmental Services Frankfort, Kentucky
Division of Forestry Frankfort, Kentucky	Kentucky Environmental Education Council Frankfort, Kentucky
Division of Waste Management Frankfort, Kentucky	Governor's Office Frankfort, KY
Kentucky Division of Water Frankfort, KY	Kentucky Natural Resources and Environmental Protection Cabinet Frankfort, KY
Kentucky Department of Fish and Wildlife Resources Frankfort, Kentucky	Kentucky State Nature Preserves Commission Frankfort, KY
Kentucky Heritage Council Frankfort, Kentucky	David H. Kessler, Ph.D. Associate Professor Of Biology Rhodes College Memphis, TN
Kentucky Water Watch, C/O Ken Cooke Frankfort, KY	U.S. Fish & Wildlife Service Division of Ecological Services Cookeville, Tennessee
State Historic Preservation Office Frankfort, Kentucky	Dept. of Natural Res. & Env. Protection Cabinet Frankfort, Kentucky
Division of Conservation Pine Hill Plaza Frankfort, Kentucky	Ernie Paquette 3001 West End Ave. Nashville, TN
Al Cross Frankfort KY	Gullett, Sanford, Robinson & Martin ATTN: Dan Haskell Nashville, Tennessee
Donald N. Jones Nashville, Tennessee	Sam Fenimore Brentwood, Tennessee
Key Financial, Inc. ATTN: Zack Jones Nashville, Tennessee	Jay Clementi Game Fair Ltd. Nashville, Tennessee
Juni Fisher Franklin, Tennessee	Lee Squires Louisville, Kentucky
Tim Johnson Nashville, Tennessee	Charles R. Miller Franklin, Tennessee

JIM CATINO ARISTA NASHVILLE NASHVILLE, TENNESSEE	WENDY SMITH, DIRECTOR WORLD WILDLIFE FUND SOUTHEAST RIVERS AND STREAMS PROJECT NASHVILLE, TN
ROBERT M. KOEHLER LOUISVILLE, KENTUCKY	JOHN CLIFF FRANKLIN, TENNESSEE
JACKSON HARRIS NASHVILLE, TENNESSEE	ROGER GUTH BRENTWOOD, TENNESSEE
DR. RICHARD DAVIS NASHVILLE, TENNESSEE	AL GIBSON CLINTON COUNTY NEWS ALBANY, KY
GARY KELLEY NASHVILLE, TN	RON KILMER WALTON, KY
GIL LACKEY NASHVILLE, TN	MERLE OLMSTED WALTON, KY
JEFF BARRRETT – MTFF CONSERVATION CHAIRMAN FRANKLIN, TN	JAMES E. PATRICK COVINGTON, KY
JEFF WADE KINGSTON, TN	WILLIAM MCDANIEL ALEXANDRIA, KY
RICK PARRISH SOUTHERN ENVIRONMENTAL LAW CENTER CHARLOTTESVILLE, VA	AARON MCDANIEL ALEXANDRIA, KY
BERNARD J. BLAU JOLLY, BLAU, KRIEGE & TURNER, P.L.L.C. COLD SPRING, KENTUCKY	CLINTON GRAY LOUISVILLE, KY
TIM GUILFOILE CINCINNATI, OH	MIKE GLINDMEYER BURLINGTON, KY
BETTY DEVITA LAKESIDE PARK, KY	JAMES WILMOTH STAMPING GROUND, KY
GARY WISNIEWSKI FLORENCE, KY	MIKE GROESCHON COLD SPRING, KY
STEVE MOERMOND COVINGTON, KY	SCOTT SPILLA INDEPENDENCE, KY
DANIEL SALVI WEST CHESTER, OH	TOM OWEN INDEPENDENCE, KY
JOE JACKMAN UNION, KY	ED JODY COVINGTON, KY
LARRY DRAKE LOUISVILLE, KY	MARK ENGLAND ERLANGER, KY
TOM RUST COLD SPRING, KY	DANIEL DYKES ALEXANDRIA, KY
A.E. SCHWARTZ LUDLOW, KY	EVELYN TRAMBARGER CINCINNATI, OH
KEVIN BREMER VILLA HILLS, KY	CRAIG TROESCHER CINCINNATI, OH
DEAN MOBY COVINGTON, KY	TOM KEENER SOUTHGATE, KY
ART VERNON FLORENCE, KY	HAL BURCH CINCINNATI, OH
DAVE DEWOLFE FLORENCE, TN	FRANK REUSING NEWPORT, KY
JUDITH HUSEMAN LAKESIDE PARK, KY	GINGER NOVAK EDGEWOOD, KY
TOM GIER FORT WRIGHT, KY	D WILLMOTH COLD SPRING, KY
DAN DYKES ALEXANDRIA, KY	JOHN STEVIE 1065 ROBERTSON ROAD TAYLOR MILL, KY 41015
FRANCIS TRAMBARGER CINCINNATI, OH	GARY TURNEY FLORENCE, KY

HARRY LEIDY III FLORENCE, KY	DON WILMOTH COLD SPRING, KY
MORRIS F. CECIL PARK HILLS, KY	ROBERT KIST LAWRENCEBURG, IN
LANNY SETTERS INDEPENDENCE, KY	JAMES C. PIERCE BURKESVILLE, KY
DAVE BARNETT CINCINNATI, OH	BERNARD BLAU FORT THOMAS, KY
TOM GARNER COVINGTON, KY	CHERYL BLAU FORT THOMAS, KY
SCOTT REUSING NEWPORT, KY	JOSEPH MELCHING BURLINGTON, KY
BRIAN BAMBERGER EDGEWOOD, KY	RICK STEGEMAN COLD SPRING, KY
RICHARD BUSHMAN WALTON, KY	DON BECHER PARK HILLS, KY
JOHN NOVAK III EDGEWOOD, KY	PAUL J. DUSING FLORENCE, KY
DAVID CAMPBELL GOSHEN, KY	ALLIGATOR NO.2 MARINA RUSSELL SPRINGS, KENTUCKY
ALEX LOCKSTEAD BURLINGTON, KY	CONLEY BOTTOM RESORT MONTICELLO, KENTUCKY
ROBERT BROCK RICHMOND, KY	JAMESTOWN RESORT AND MARINA LTD JAMESTOWN, KENTUCKY
STEVE HAUBNER FALMOUTH KY	LEE’S FORD MARINA RESORT SOMERSET, KENTUCKY
JOSEPH MOHLENKAMP CINCINNATI, OH	LAKE CUMBERLAND STATE PARK JAMESTOWN KY
PAUL STEGEMAN COLD SPRING, KY	CLINTON COUNTY PUBLIC LIBRARY ALBANY KY
MARY STEGEMAN COLD SPRING, KY	PULASKI COUNTY PUBLIC LIBRARY SOMERSET KY
THOMAS BADER WALTON, KY	MCCREARY COUNTY PUBLIC LIBRARY WHITLEY CITY KY
JOSHUA RUST INDEPENDENCE, KY	POSTMASTER UNITED STATES POSTAL SERVICE SOMERSET, KY
EMMET BOYERS ALEXANDRIA, KY	POSTMASTER UNITED STATES POSTAL SERVICE WHITLEY CITY, KY
KEITH HAUNGS CINCINNATI, OH	THE HONORABLE DONNIE MCWHORTER JUDGE EXECUTIVE, CLINTON COUNTY ALBANY KY
J. MICHAEL NOLL COVINGTON, KY	THE HONORABLE DARRELL BESHEARS JUDGE EXECUTIVE, PULASKI COUNTY SOMERSET KY
BRYAN VERONA KY	J.P. WILES, MAYOR CITY OF SOMERSET SOMERSET, KY
RESOURCE MANAGER’S OFFICE LAKE CUMBERLAND SOMERSET, KENTUCKY	CITY OF MONTICELLO THURSTON FRYE, MAYOR MONTICELLO, KY
GRIDER HILL MARINA ALBANY, KENTUCKY	VOLUNTEER BARGE NASHVILLE TN
LAKE CUMBERLAND STATE DOCK JAMESTOWN, KENTUCKY	USFWS MR. LEE BARCLAY COOKEVILLE, TN
THE FRIENDS OF LAKE CUMBERLAND, INC. BURNSIDE, KENTUCKY	MR. HERBERT HARPER, THC SHPO ATTN: MR. JOE GARRISON CLOVER BOTTOM MANSION NASHVILLE, TN

RUSSELL COUNTY PUBLIC LIBRARY JAMESTOWN KY	COMMISSIONER JUSTIN WILSON, TDEC ATTN: MR. G. DODD GALBREATH TDEC ENVIRONMENTAL POLICY OFFICE NASHVILLE, TN
WAYNE COUNTY PUBLIC LIBRARY MONTICELLO KY	MR. REGGIE REEVES TDEC DIVISION OF NATURAL HERITAGE NASHVILLE, TN
POSTMASTER UNITED STATES POSTAL SERVICE JAMESTOWN, KY 42629	FARM SERVICES AGENCY MR. DAVID MCDOYLE, EXECUTIVE DIRECTOR NASHVILLE, TN
POSTMASTER UNITED STATES POSTAL SERVICE MONTICELLO, KY	TDECD NEPA CONTACT MR. WILTON BURNETT NASHVILLE, TN
POSTMASTER UNITED STATES POSTAL SERVICE ALBANY, KY	MR. BOB ALLEN NASHVILLE, TENNESSEE
THE HONORABLE RONNIE MCFALL JUDGE EXECUTIVE, RUSSELL COUNTY JAMESTOWN, KY	MR. GREG DENTON TDEC DIVISION OF WATER POLLUTION CONTROL NASHVILLE, TENNESSEE
THE HONORABLE BLAINE PHILLIPS JUDGE EXECUTIVE, MCCREARY COUNTY WHITLEY CITY KY	MR. DAVID DRAUGHON DIVISION OF WATER SUPPLY NASHVILLE, TENNESSEE
JOHN N. "NICKY" SMITH, MAYOR ALBANY, KY	MR. JIM HAYNES DIVISION OF SUPERFUND NASHVILLE, TENNESSEE
MAYOR JUNE MCGAHA JAMESTOWN, KENTUCKY	MR. HERBERT HARPER, THC SHPO ATTN: MR. NICK FIELDER CLOVER BOTTOM MANSION NASHVILLE, TN
TWRA NEPA CONTACT MR. ROBERT TODD NASHVILLE, TN	MR. MICHAEL MOBLEY DIVISION OF RH NASHVILLE, TENNESSEE
MS. ANN MURRAY TENNESSEE CONSERVATION LEAGUE NASHVILLE, TN	JOHN L. HEWITT ENVIRONMENTAL PERMITS SECTION TN DEPARTMENT OF TRANSPORTATION MESSENGER SERVICE
CAROL MARTIN SMYRNA, TN	PETE CONNOLLY NATIONAL PARKS CONSERVATION ASSOCIATION KNOXVILLE, TENNESSEE
TDEC - MR. DAN EAGAR NASHVILLE, TN	DAVID H. KESSLER, PH.D. ASSOCIATE PROFESSOR OF BIOLOGY RHODES COLLEGE MEMPHIS, TN
NATURAL RESOURCES CONS. SVC. STATE CONSERVATIONIST NASHVILLE, TN	GENE COTTON FRANKLIN, TN
TENNESSEE VALLEY AUTHORITY MR. JON M. LONEY ENVIRONMENTAL MANAGEMENT KNOXVILLE, TN	DON OWENS WATER POLLUTION CONTROL, KEAC SURFACE MINING SECTION KNOXVILLE TN
TENNESSEE STATE PLANNING OFFICE NASHVILLE, TENNESSEE	DORENE BOLZE HARPETH RIVER WATERSHED ASSN. FRANKLIN, TN
TN DEPARTMENT OF AGRICULTURE MR. LOUIS BUCK, DEPUTY COMMISSIONER ELLINGTON AGRICULTURAL CENTER NASHVILLE, TENNESSEE	JOE MCCALEB HENDERSONVILLE, TN

TN DEPT OF TRANSPORTATION (TDOT) MR. GLEN BECKWITH, PLANNING DIV NASHVILLE, TN	BARRY SULKIN NASHVILLE, TN
MS. JOYCE HOYLE DIVISION OF RECREATION SERVICES NASHVILLE, TENNESSEE 37243	CLAYTON MINCHEW TVA KNOXVILE TN
MR. JOHN WALTON DIVISION OF AIR POLLUTION CONTROL NASHVILLE, TENNESSEE	DON RIMANN TN AMERICAN WATER CO CHATTANOOGA TN
MR. KENT TAYLOR DIVISION OF GROUND WATER PROTECTION NASHVILLE, TENNESSEE	LAROSA COLLIER STATE OF TENNESSEE RAIL & WATER DEPT NASHVILLE TN
MR. CHUCK HEAD DIVISION OF UST NASHVILLE, TENNESSEE	SANDRA SILVEY US FISH & WILDLIFE 446 NEAL ST COOKEVILLE TN 38501
MR. TOM TIESLER DIVISION OF SOLID WASTE MANAGEMENT NASHVILLE, TENNESSEE	BECKY BURTON CONSERVATION & NATURAL RESOURCES MONTGOMERY AL
US ENVIRONMENTAL PROTECTION AGENCY REGION IV – WETLANDS SECTION ATLANTA, GEORGIA	CHOO CHOO CITY DREDGING CHATTANOOGA TN
WILLIAM B CALDWELL COLUMBIA TN	JON HORNSBY AL GAME & FISH DIV MONTGOMERY AL
ENVIRONMENTAL SECTION DEPUTY ATTORNEY GENERAL ATTORNEY GENERAL AND REPORTER NASHVILLE, TENNESSEE	HAROLD DRAPER TVA KNOXVILLE TN
ANDREW E TOLLEY TN DIV OF WATER POLLUTION CONTROL JOHNSON CITY TN	INTERNATIONAL DREDGING FT COLLINS CO
J. DOUGLAS FRITZ, CPESC, CFP WATER QUALITY COORDINATOR CITY OF CHATTANOOGA STORMWATER MANAGEMENT CHATTANOOGA, TN	LYLE BENTLEY TDEC NASHVILLE TN
LESLIE COLLEY THE NATURE CONSERVANCY COLUMBIA, TN	BENNETT GRAHAM TVA NORRIS TN
TOM HEINEKE HEINEKE & ASSOCIATES BARTLETT, TN	TN COMMISSION OF INDIAN AFFAIRS NASHVILLE TN
D W COUTS SPRINGFIELD TN	EVA LONG NATIONAL PARKS SERVICE 1924 BUILDING ATLANTA GA
DON WALDON TN TOMBIGBEE WATERWAY COLUBUS MS	MARY ANN PECKHAM MURFREESBORO TN
J BENNETT GRAHAM TVA NORRIS TN	CRAIG STUBBLEFIELD TUPELO MS
ROBBIE BAKER TDEC (WPC-7TH FLOOR) NASHVLLE TN	RICHARD HANKS DOVER TN
STEVE CULP W L HAILEY & CO INC NASHVILLE TN	MARK COREY GREENEVILLE TN

ANDEW SWANK W L HAILEY & CO NASHVILLE TN	TIM GILBERT TVA SERVICE BLDG 1M MUSCLE SHOALS AL 35662-
MARK S MCNELLY TVA NORRIS TN	JAMES CURRY ADAMS TVA RESERVATION RD MUSCLE SHOALS AL
ERIC SOMERVILLE EPA REGION 4 WETLANDS ATLANTA GA	BUFF L CROSBY TVA MUSCLE SHOALS AL
K PRINTZ TVA CHATTANOOGA TN	ALABAMA HIST COMM MONTGOMERY, AL
MICHAEL W RUSHING RUSHING MARINE CORPORATION JACKSON MO	BILLY HARTSELL KY STATE ENGINEER FRANKFORT KY
LYNDA LEMAY USDA/NRCS NASHVILLE TN	COLIN BAGWELL HUNTSVILLE AL
CATHERINE MEYER UNIVERSITY OF ALABAMA MUSEUMS MOUNDVILLE AL	HARPETH RIVER WATERSHED ASSOCIATION FRANKLIN TN
TN CONSERVATION LEAGUE NASHVILLE TN	UNIVERSITY OF ALABAMA MUSEUMS ROBERT A CLOUSE TUSCALOOSA AL
MATERIALS INERNATIONAL INC ATLANTA GA	MATT STEVENSON DOCKS HARDWARE & MARINE FABRIC TERRYVILLE CT
DANIELLE DROITSCH TN CLEAN WATER NETWORK KNOXVILLE TN	DAVID L. MORGAN KENTUCKY HERITAGE COUNCIL FRANKFORT KY
HAYWOOD HARRELL SHILOH TN	PEERSON CONSTRUCTION COMPANY BIRMINGHAM AL
KRISTIN STOEHR WARTBURG TN	JAN CASEY JONES TN RIVER VALLEY ASSOCIATION DECATUR AL
REED DETRING ONEIDA TN	BAY WEST INC SAINT PAUL MN
MARK WOODS MIDDLESBORO, KY	RANDY MCCANN TVA, ELK DUCK WATERSHED TEAM CTR 2U MUSCLE SHOALS AL
BONNIE FERGUSON TVA ELK/DUCK WATERSHED TEAM MUSCLE SHOALS AL	JIM DAWSON TVA NORRIS TN
RICHARD L TOENNISSON TVA MIDEAST REGION LENOIR CITY TN	ROGER A MILSTEAD TVA KNOXVILLE TN

7.0. Previous Studies Incorporated by Reference.

Environmental Assessment: Wolf Creek Dam Seepage Reduction Study. An EA was completed for the proposed repairs at Wolf Creek Dam. The EA recommended implementing a combination of a grout curtain and a new concrete cutoff wall in the earthen embankment as the environmentally preferred alternative. A FONSI was signed in January 2005, for this work.

Environmental Assessment: Halcomb's Landing Relocation Study. An EA was completed for a proposed relocation of Halcomb's Landing to an adjacent site. Combining the relocation of the boat ramp and parking area with the conversion of the existing parking area to a construction laydown site was the recommended plan. A FONSI was signed in March 2006, for this work.

The Continued Operation Maintenance and Management of Wolf Creek Dam Lake Cumberland Kentucky Final Environmental Impact Statement. This document, dated March 1976, was written to evaluate impacts of continued operation, maintenance, and management of Wolf Creek Dam and Lake Cumberland Reservoir.

8.0. Index

Appendix A

Biological Assessment and Biological Opinion

US Army Corps
of Engineers

Nashville District

WOLF CREEK DAM/LAKE CUMBERLAND
RUSSELL COUNTY, KENTUCKY

CHANGES TO
OPERATIONAL GUIDE CURVES POOL ELEVATIONS

BIOLOGICAL ASSESSMENT

US Army Corps of Engineers

December 2007

TABLE OF CONTENTS

1.0. Introduction

The Corps of Engineers, Nashville District, is preparing a Final Environmental Impact Statement (FEIS) to address proposed operational changes at Wolf Creek Dam that could affect pool elevations in Lake Cumberland. Wolf Creek Dam is located in Russell County in south central Kentucky.

Wolf Creek Dam, impounded in the early 1950s, was built on karst geology using accepted engineering practices of the day. Since the 1960s, seepage flows through the dam's right abutment and left rim wall have been monitored. Repairs have been made at various times and include grout injection into the dam foundation and a concrete diaphragm wall. These repairs were effective; however recent increased seepage has become a concern. A comprehensive plan to repair the dam was approved, but will take a number of years to complete. The plan includes a major grouting project which began in 2007, to address the dam seepage, followed by installation of a cutoff wall through the main dam. These repairs along with other alternatives were discussed in the following NEPA document: *Environmental Assessment: Wolf Creek Dam Seepage Reduction Study*. A Finding of No Significant Impact (FONSI) was signed for this document in January 2005.

Since March 2005, the Corps has attempted to keep fall, winter and early spring lake levels from extreme rises due to high inflow. Seepage problems are made worse during continual high lake levels. In 2007 the Corps initiated an emergency drawdown to reduce pressure on the foundation. Until repairs are sufficiently complete, the Corps has determined that it is in the public's interest to operate Lake Cumberland at a flatline pool at elevation 680 (mean sea level). This is approximately 43 feet below the normal summer pool elevation. This Biological Assessment has been prepared to support an Environmental Impact Statement that is being prepared concurrently.

This Biological Assessment (BA) is necessary to provide a basis for informal or formal (if required) Section 7 Consultation and for National Environmental Policy Act (NEPA) compliance to address impacts that could occur due to possible changes in lake levels

1.1. Purpose Statement

The primary objective of this informal Section 7 consultation process is to determine if lowering the lake levels below the normal guide curves at Lake Cumberland may adversely affect federally listed species or designated critical habitat. If so, the Corps Nashville District will enter formal consultation, and the USFWS will develop reasonable and prudent measures and incidental take terms and conditions while required repairs are effected.

1.2. Scope

The Corps of Engineers Nashville District is committed to full compliance with the Endangered Species Act regarding its operations and maintenance activities on the Cumberland River. Because the lower pool elevations have the potential to affect TVA operations at two fossil fuel power plants, the Corps has requested that TVA serve as a cooperating agency for the EIS. The geographical areas to be addressed in this Biological Assessment and informal Section 7 consultation process consist of the Cumberland River from its mouth through Barkley, Cheatham, and Old Hickory, Cordell Hull, and Cumberland lakes, and Kentucky Lake and its tailwaters on the Tennessee River. Paragraph 3.1 and Table 1 below further defines the action area and multi-purpose projects within the study areas of the Tennessee and Cumberland River systems. The table also provides Internet links to the Navigation Charts (river mapping) for those rivers and projects. This Biological Assessment examines impacts of the possible lowered operating levels associated with Dam repairs to determine whether any are likely to adversely affect federally listed species or designated critical habitat. This process does not consider the effects of construction which was covered under previous NEPA assessments.

1.3. Previous NEPA Documents, Section 7 Consultations, and Studies.

Final Environmental Impact Statements for open channel maintenance of the Tennessee River and tributaries and for operation, maintenance and management of water resource projects on the commercially navigable portion of the Cumberland River were filed in March 1976 and November 1975, respectively. Both were prepared as composite or “umbrella” statements as defined in Corps implementing regulations at the time (ER 1105-2-507). Both statements followed fairly closely the enactment of the Endangered Species Act, and clear implementation procedures for Section 7 of the Act had not been established. Also many species had not yet been federally listed. Endangered Species Act compliance was not raised as an issue in the agency review comments. These “umbrella” statements were followed-up by site specific NEPA Documents as each substantial specific operation and maintenance action was proposed. Section 7 compliance was completed for each individual action, when appropriate, within the respective individual NEPA processes and under the consultation regulations in effect at the time.

In July, 2007 the Corps submitted a BA titled, Biological *Assessment Operation and Maintenance of the Tennessee and Cumberland Rivers Navigation Systems*, to determine if any Corps of Engineers operation and maintenance activities associated with navigation along the Tennessee/Cumberland Rivers adversely affect federally listed species or designated critical habitat. A list of previous NEPA Documents and/or Section 7 consultations and studies related to the Tennessee and Cumberland Navigation Systems is provided in Appendix B.

Numerous reports and studies have been completed at Wolf Creek Dam and Lake Cumberland and are cited in the document titled, *Wolf Creek Dam, Jamestown, Kentucky,* *Seepage Control, Major Rehabilitation Evaluation Final Report, LRD Review, July 11, 2005*. These documents include Lake Cumberland Master Plans, O&M Plans, Continued Operation, Maintenance, and Management EA, design plans, security plans, spill plans, and more. During the study process, additional alternatives were identified for the main dam embankment and an EA was completed and a FONSI. Rehabilitation alternatives considered, potential impacts analyzed, and public and agency comments considered were included in the EA. It was titled, *Wolf Creek Dam Seepage Reduction Study, January 2005*.

2.0. Description of the Tennessee and Cumberland River Systems

2.1. History and Authority

The River and Harbor Act of 3 July 1832 authorized the first open-channel work on the Cumberland River (U.S. Army Corps of Engineers, Nashville District. 1975). Since then, the Corps of Engineers, Nashville District has been responsible for planning, construction, operation, maintenance and management of facilities, waters, and lands associated with water resource development projects in the Cumberland River Watershed.

In the early part of the 20th century, major floods occurred in the Ohio and Mississippi River basins, which resulted in disastrous losses of lives, property, and economic stability. Ensuing public outcry for government agencies to take protective measures led to the development in 1937 of a comprehensive flood control plan by the U.S. Army Corps of Engineers (Corps). The comprehensive plan proposed construction of 45 flood control reservoirs in the Ohio River basin. Six flood control reservoirs were recommended for the Cumberland River Basin, of which four were eventually built. These four are Wolf Creek (Lake Cumberland), Dale Hollow, Center Hill, and J. Percy Priest Dams.

The Flood Control Act of 1938 authorized dam construction for Wolf Creek Dam. Supplementing authorizations were the Third Supplemental Defense Act of 1941, the Flood Control Act of 1944, and the River and Harbor Act of 1946. Section 4 of the Flood Control Act of 1944 authorized the Chief of Engineers to construct, maintain, and operate public park and recreational facilities and to permit construction, maintenance and operation of such facilities. The Federal Water Project Recreation Act of 1965 established development of the recreational potential at federal water resource projects as a full project purpose. The Fish and Wildlife Coordination Act (16 USC 661) and the Fish and Wildlife Conservation Act of 1980 (16 USC §§ 2901 – 2911) recognized "…the vital contribution of our wildlife resources to the Nation…" and provided that "…wildlife conservation shall receive equal consideration and be coordinated with other features of water-resource development programs…" The Clean Water Act (33 U.S.C. 1252 § 102(b)) added water quality to the Corps' mission at water-resource development projects. The River and Harbor Act of 1958 (43 U.S.C. 390b), authorizes the Secretary of the Army to include municipal and industrial water storage in Corps projects and to reallocate storage in existing projects to municipal and industrial water supply.

As a result of these legislative actions, the currently authorized project purposes for the Wolf Creek Dam/Lake Cumberland Project are flood control, hydropower generation, recreation, fish and wildlife management, and water quality. Although not specifically authorized for the purpose, Wolf Creek Dam also makes some contribution to navigation as a by-product of its releases, particularly on the lower Ohio and Mississippi Rivers.

2.2. Description of Reservoirs

The Corps of Engineers constructed, operates, and maintains ten dams in the Cumberland River Basin. All of the dams are operated as multiple-use projects, although not all dams can support all uses. The “mainstem” dams, Barkley, Cheatham, Old Hickory, and Cordell Hull were all authorized and designed for navigation and have locks associated with the dams. The other six dams, including Wolf Creek Dam, are considered “tributary” dams. All of the dams and reservoirs are, of necessity, operated as a single system. The vast majority of the water that passes through the mainstem lakes originates at one of three large reservoirs, Lake Cumberland (Wolf Creek Dam), Dale Hollow, and Center Hill. In a typical year, Lake Cumberland supplies about 60% of the water in the Cumberland River, with Dale Hollow and Center Hill each supplying between 15% and 18%. How these reservoirs are operated, and the timing and volume of their releases is, therefore, of great concern for all of the downstream resources.

Wolf Creek Dam is a large, high head dam located near Jamestown, Kentucky at Cumberland River Mile 460.9 (Figure 1). It controls runoff from a drainage area of approximately 5,789 square miles. The dam is a combination earth fill and concrete structure 5,736 feet long and 258 feet high, with a gated spillway structure. It was originally designed for flood control and hydropower generation. Subsequent authorizations added water quality, recreation, fish and wildlife management, and water supply to the project purposes. The theoretical lake retention time is 129 days and the length of the pool is 101 miles. The length, depth, and retention time have combined to alter the lake and particularly the tailwater from a warm-water fishery to a cold-water fishery. The tailwater of Wolf Creek Dam flows approximately 70 miles downstream into the upper end of Cordell Hull Lake near Celina, Tennessee. Lake Cumberland typically has a winter pool elevation of about 690. Under normal conditions, late winter and spring rains are captured and retained to reduce flooding downstream and to store the water for later use. Usually Lake Cumberland is allowed to fill to elevation 723 by the Fourth of July. This is done in part for recreational enhancement, but primarily to allow peaking hydropower generation during the summer when power demands are greatest and to supply fresh water to sustain water quality in the mainstem lakes. From about the Fourth of July on Lake Cumberland is slowly drained until the winter lake levels are reached and the cycle begins once again.

Cordell Hull Lock and Dam, located on the Cumberland River at mile 313.5 in Smith County, Tennessee, is approximately 5 miles upstream from Carthage, Tennessee. The lake extends 67.3 miles upstream to Celina, Tennessee, and is a mainstream storage impoundment on the Cumberland River. Its primary authorization was for recreation, navigation, and hydropower production. Other authorized project purposes now include water quality, municipal and residential water supply, and fish and wildlife management. Cordell Hull has no flood storage capacity and its water level fluctuates about five feet annually. Its tailwaters flow into Old Hickory Lake.

Old Hickory Lock and Dam, located on the Cumberland River at mile 216.2 in Sumner and Davidson Counties, Tennessee, is approximately 25 miles upstream from Nashville, Tennessee. The lake extends 97.3 miles upstream to Cordell Hull Lock and Dam near Carthage, Tennessee. Old Hickory Lock and Dam was authorized for construction by the Rivers and Harbors Act of 1946 as a unit of a comprehensive development plan for the Cumberland River Basin and is a mainstream storage impoundment on the Cumberland River. Its primary authorization was for navigation and hydropower production. Other authorized project purposes now include recreation, water quality, municipal and residential water supply, and fish and wildlife management. Old Hickory has no flood storage capacity and its water level fluctuations are minimal. Its tailwaters flow into Cheatham Lake.

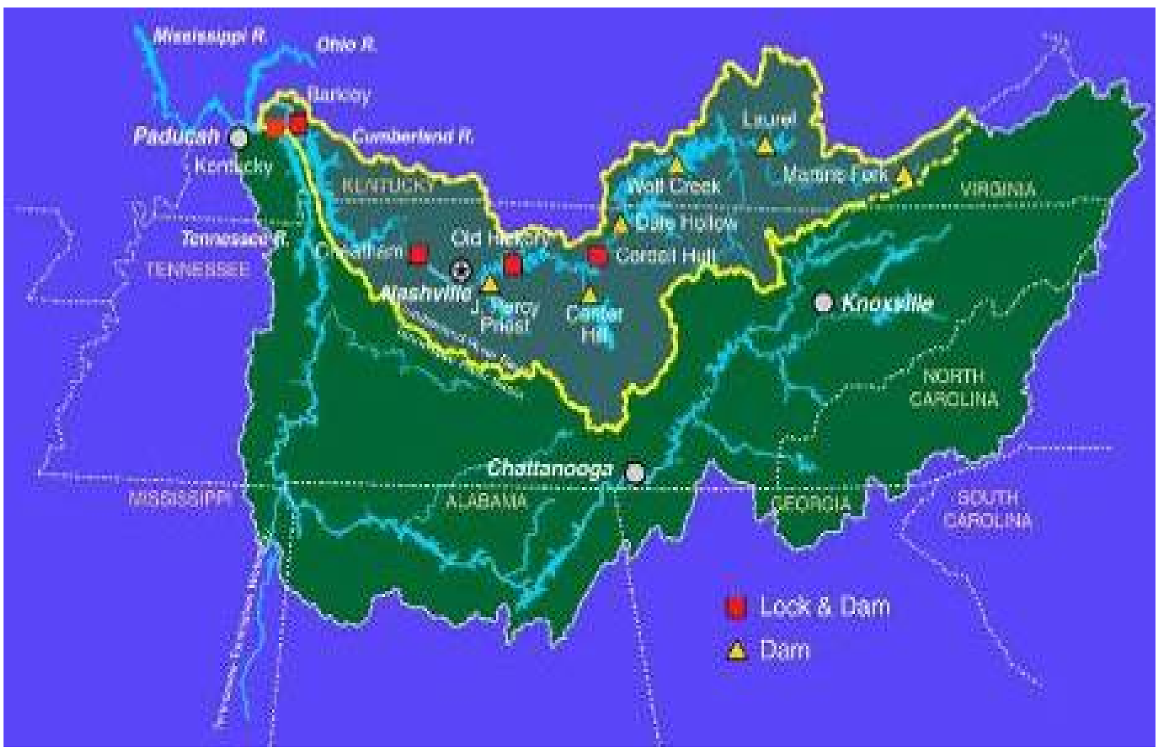


Figure 1

Congress authorized the Cheatham Lock and Dam Project in 1946 as a navigation unit of a comprehensive plan of development for the Cumberland River Basin. The original purpose of this water resources development project was to replace three smaller, aging locks built at the turn of the century. In 1952, Congress added authorization for the production of hydroelectric power as a project function. The lake is a “run-of-the-river" type that operates basically on normal streamflow. The Corps uses as much of the inflow as practicable for hydropower generation. The dam was not constructed to provide a designated capacity for regulating floodwaters. Therefore, during periods of heavy rainfall and high streamflow, the spillway gates are opened to pass waters in excess of the capacity of hydropower turbines. Cheatham Lock and Dam backs water for 67.5 miles to Old Hickory Lock and Dam. Other authorized project purposes now include recreation, water quality, municipal and residential water supply, and fish and wildlife management. Cheatham's tailwaters flow into Lake Barkley.

Lake Barkley is a multi-purpose project designed for flood control, navigation, and hydropower. Other authorized project purposes now include recreation, water quality, municipal and residential water supply, and fish and wildlife management. Located at Cumberland River Mile (CRM) 30.6, Barkley Lock and Dam on the lower Cumberland River functions as an auxiliary lock for the Kentucky Lock since the Barkley Lock is accessible to Tennessee River traffic through the Barkley Canal. Two additional purposes for which Lake Barkley is managed are recreation and fish and wildlife. It has a 118.1 backwater which ends at Cheatham Lock and Dam. Below Barkley Lock and Dam the Cumberland River flows to its confluence with the lower Ohio River. The tailwater is greatly influenced by backwater from Lock and Dam 52 and the discharges from Smithland Lock and Dam on the Ohio River.

Kentucky Lake is on the Tennessee River, but is connected to Lake Barkley by a 1.5-mile long unregulated canal that connects the Tennessee and Cumberland Navigation Systems. The Nashville District operates and maintains the locks at this project, while TVA operates and maintains the associated dam, pool, and hydropower facilities. It is because of the connection through the canal that Kentucky Lake is included in this BA. Kentucky Lock and Dam are located at Tennessee River Mile (TRM) 22.4. Kentucky Lock and Dam (TRM 22.4) backs up water for 184 miles to Pickwick Lock and Dam.

As previously mentioned, Barkley Lock and Dam also has a collateral function as an auxiliary lock for Kentucky Lock since it is accessible to Tennessee River traffic through the Barkley Canal. The Nashville District has primary responsibility for operation, maintenance, and management of the multi-purpose projects including hydropower, flood control, water supply, fish and wildlife, navigation, and recreation. In addition to operating, maintaining and managing the four lock and dam projects and Wolf Creek Dam, the Nashville District is responsible for operating and maintaining five other tributary projects. These are J. Percy Priest, Dale Hollow, Center Hill, Laurel River, and Martins Fork Lakes. None of these is of direct concern for this BA although their flows do influence the cumulative impacts.

The Cumberland River is considered a very scenic river with numerous historic locations along the shoreline. It draws many of the same large inland cruise ships each year that run the Tennessee River. The major difference is they only travel 190 miles up the Cumberland to Nashville, Tennessee. Commercial traffic is comprised primarily of barges loaded with commodities and raw materials. Tows traveling the Cumberland River typically consist of nine to twelve barges. Each year approximately 23.0 million tons of commodities are transported on the Cumberland River. Commodities most often shipped on the Cumberland parallel those seen on the Tennessee River.

2.3. General Environmental and Socioeconomic Setting of the Region

Although dated, the "umbrella" environmental impact statements referenced in Paragraph 1.3 above included the most comprehensive description of the environmental and socioeconomic setting of the twin navigation systems available at the time and until the turn of the 21^{st} century. The Programmatic Environmental Impact Statement for the Tennessee Valley Authority Reservoir Operations Study provides a contemporary description of the Tennessee River Valley setting, although coverage is much broader than the navigable portion of the Tennessee River. There is no contemporary comprehensive description of the Cumberland River System, although limited individual project NEPA documents and resource assessments provide localized descriptions of the setting along the river corridor.

2.3.1. Cumberland River System

The Cumberland River is formed by the confluence of the Poor and Clover Forks of the Cumberland River near Harlan, Kentucky some 692.8 miles above its mouth at the Ohio River at Smithland, KY. With a drainage area of 17, 598 square miles and navigable length of 381.0 miles, the Cumberland River could in many ways be considered a scaled-down twin of the Tennessee River. The river flows through three Physiographic Regions; the Highland Rim, Central Basin and Pennyroyal Plateau Regions. The Cumberland River Watershed is characterized by Karst topography. Within the navigable length of the river, the slope averages a low to moderate 0.52 feet per mile, more gradual than the slope of the Tennessee River. The majority of the navigable portion of the river meets both state and federal water quality criteria and guidelines, except the lower portion (Livingston Co., KY) which is affected by the presence of pathogens from septic tanks, municipal sewage treatment plants, sewer overflow, land disposal, and agriculture.

As previously mentioned, the Tennessee-Cumberland River ecoregions have the highest number of fish, crayfish mussels and endemic species in North America; however, the greatest diversity in the Cumberland System is upstream of the navigation system, i.e., beyond the scope of this BA. The water quality and physical environment of the Cumberland River were significantly altered with the construction of the reservoir system when free-flowing river habitat was converted to reservoir pools. A higher proportion of the Cumberland Navigation System retains riverine characteristics in comparison with the Tennessee, but the river flows slower because of the low to moderate gradient. In addition to the conversion from riverine habitat to reservoir pools, a cold water fishery developed in the upper portion of the navigation system due to the discharge of Wolf Creek, Center Hill, and Dale Hollow dams as well as construction of the relatively deep Cordell Hull Reservoir. As a result, a combination of lotic, lentic, warm and cold water species inhabit the navigable portion of the Cumberland River, with the majority of the fishery being warm water. The mussels of the navigable Cumberland River are characterized by relatively poor quality shells, and have little commercial demand. As a result, little emphasis has been placed on their study, and most available data is related to proposals such as maintenance dredging. There are, however, viable sport and commercial fisheries with the sport fishery notably flourishing from Cordell Hull Dam downstream.

There are three major forest types in the Cumberland River Watershed; Bottomland Hardwood, Western Mesophytic, and Cedar Glade. Of these, the Bottomland Hardwood and Western Mesophytic types generally characterize the study area. A mosaic of forest and agricultural lands with corresponding wildlife diversity dominate the lands surrounding the system, except in the larger population centers of Clarksville – Montgomery County, Tennessee and the Nashville – Davidson, Tennessee SMSA (Standard Metropolitan Statistical Area). The population centers along the river are rapidly growing, and the primary threats to terrestrial plant and animal communities are loss of habitat to human development and introduction of exotic invasive species. Based on informal observation, residential development is the most prevalent developed land use around the system, although two major recreational marinas are proposed in the Nashville area.

Social and economic resources in the Cumberland River Valley Region have generally grown since 1990. The population has grown at a greater rate than the overall state rate for the more rural counties and at a lesser rate for Metropolitan Nashville – Davidson County, reflecting a trend away from that large population center. Since 1990, employment has increased throughout the study area, with unemployment remaining in the single digits, ranging from 3.4% to 8.7% (for Stewart County, TN, which has traditionally had a depressed economy). The region has a high percentage of its workers employed in the service, goods-producing, and construction sectors and a lower share of its workers in the mining, farming/fishing/ forestry and government sectors. Navigation, along with power supply, water supply, transportation corridors and other factors, is considered a direct economic driver for the region.

2.3.2. Tennessee River System

The Tennessee River is formed by the confluence of the French Broad and Holston Rivers at Tennessee River Mile 652.0 and drains approximately 41,000 square miles in seven states. The only portion of the river that this BA is concerned with is between the mouth of the river at its confluence with the Ohio River, through Kentucky Lock and Dam up to Pickwick Lock and Dam. This portion of the Tennessee River flows through two physiographic regions, the Southeastern Plains and the Interior Plateau in portions of Tennessee, Mississippi, and Kentucky. The area is characterized by Karst topography. The average slope of the navigable portion of the river is gradual at 0.77 feet per mile (Tennessee Valley Authority, 2004). The Kentucky Lake is highly regulated, with free flowing reaches only in the Pickwick tailwater[1]. The relatively heavy

[1] a stream segment downstream of a dam, in which the discharge and resulting flows create river-like conditions similar to those of an unimpounded stream.

annual rainfall of 50 – 60 inches is concentrated in the cool months of the year, with March usually being the wettest month. Average annual temperature ranges from 56.3 degrees F to 60.1 degrees F, depending on location within the valley. July and August are the warmest months, and January is the coolest. Current air quality meets the National Ambient Air Quality Standards (NAAQS). Kentucky Lake and tailwater meet both state and federal water quality criteria and guidelines.

The Tennessee-Cumberland River ecoregions have the highest number of fish, crayfish mussels and endemic species in North America, and the Tennessee is the most diverse temperate freshwater ecosystem in the world (Tennessee Valley Authority, 2004). With the construction of the TVA and Corps reservoir systems both the water quality and physical environment of the rivers were significantly altered. The reservoir system's primary impact was to convert free-flowing river habitat to reservoir pools. Many riverine[2] species, especially mollusks, minnows and darters, could not adapt to the switch in environments and were extirpated from their former habitats. For a number of species that were not extirpated, the habitat alterations affected their abundance so that they became rare and are listed as state or federal threatened or endangered species. Some riverine species continue to live in remnant habitats that mimic riverine conditions, while other species that thrive in impoundments have increased in abundance and expanded their ranges. For example, freshwater mussels adapted to riverine conditions are the largest category of threatened or endangered species in the system and are doing poorly, while mussels that are adapted to pool; conditions are doing well. The best surviving riverine mussel communities are in the tailwaters, defined as the flowing mainstem river reaches below dams, but their status there is still only fair. Recent efforts have improved tailwater habitats, and state and federal agencies are reintroducing experimental populations of rare native species to some tailwater areas. On the other hand, there are thriving commercial and sport fisheries in the system, based on species of fish and mussels that are well adapted to impounded waters.

3.0 Approach and Process

This assessment was begun as a part of a study of the potential impacts of lowering Lake Cumberland until foundation and structural problems with Wolf Creek Dam can be rectified. After declaring an emergency, Lake Cumberland was lowered in 2007 to a flatline elevation of 680, i.e., 43 feet below the normal summer pool and five to ten feet below the usual winter pool. Starting with the broadest possible scope for the action area, activities and species, the scope was then narrowed, based on scientifically valid reasoning, until it reached a focus on the relevant action area, activities and species. All three elements of the BA – the action area, activities list, and species list – were considered as starting points, to be amended should additional information become available during preparation of the BA.

---

[2] related to, or resembling a river.

3.1 Defining the Action Area

Definition of the action area was determined to be Lake Cumberland itself and all of the downstream waterways affected by the Lake Cumberland waters, to their confluence with the Ohio River. This includes Cordell Hull, Old Hickory Lake, Cheatham Lake, Lake Barkley, and the Barkley tailwater. Kentucky Lake and its tailwater were also included due to its connection with the Cumberland River in Lake Barkley via an unregulated navigation channel and it is included when discussing the mainstem lakes. To ensure that all species of concern were included, the U.S. Fish and Wildlife Service and the state's natural heritage agencies were contacted and all federally threatened or endangered species listed in any county adjoining the waterways were included. Each species was then considered individually with regard to whether or not a prolonged lowering of Lake Cumberland would impact the species. Upstream and tributary projects on the Cumberland and Tennessee River Systems were quickly eliminated from the action area because they are not affected by the operations of Wolf Creek Dam (i.e. water is already coming through the dams for other purposes. TVA may release waters from its Tennessee River system above Pickwick Lock and Dam, but TVA's activities are outside the scope of this BA. Table 1 delineates these waters. Landward boundaries of reservations and facilities are included in the action area and the full terrestrial extent of the action area is "case-by-case" based on the species and the impact area of each specific activity.

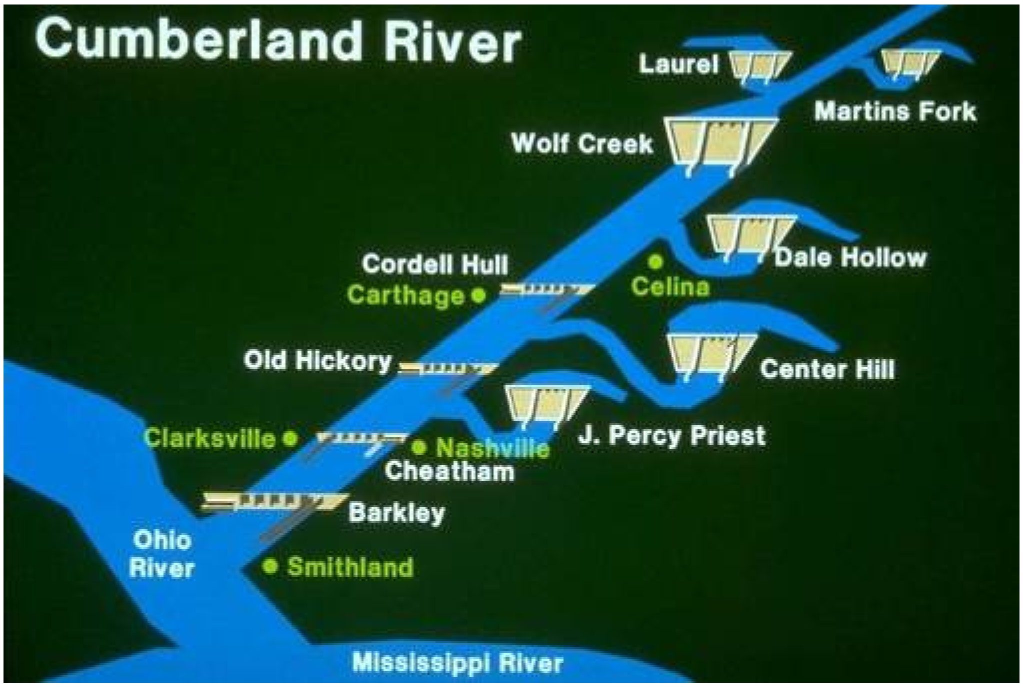


Figure 2

Table 1

Study Areas
Tennessee and Cumberland River Systems by River Mile

WATER COURSE	MILE (Start)	MILE (End)	Navigation Chart Reference
Cumberland River	**0.0**	**389.0**	http://www.lrn.usace.army.mil/opn/CumbRiver/ (Use this Internet link for waterways listed below.)
River below Lake Barkley	**0.0**	**30.6**	
Lake Barkley	**30.6**	**148.6**	
Lower Barkley	30.6	102.3	
Barkley Canal	0.0	1.5	
Hammonds Creek	0.0	1.7	
Lick Creek	0.0	6.4	
Eddy Creek	0.0	7.0	
Little River	0.0	18.0	
Upper Barkley	102.3	148.6	
Red River	0.0	10.8	
Cheatham Lake	**148.7**	**216.1**	
Lower Cheatham	148.7	166.0	
Harpeth River	0.0	10.3	
Upper Cheatham	166.0	216.1	
Old Hickory Lake	***216.2***	***313.4***	
Lower Old Hickory	216.2	265.0	
Drakes Creek	0.0	4.0	
Spencer Creek	0.0	11.0	
Station Camp Creek	0.0	3.0	
Bledsoe Creek	0.0	4.8	
Barton Creek	0.0	6.7	
Spring Creek	0.0	6.8	
Upper Old Hickory	265.0	313.4	
Cordell Hull Lake	313.5	389.0	
Defeated Creek	0.0	3.4	
Wolf Creek Tailwater /Cumberland River	389.0	460.9	
Lake Cumberland	460.9	561.9	

Table 1 Continued

Tennessee River	**0.0**	**652.0**	http://www.lrn.usace.army.mil/opn/TNRiver/ (Use this Internet link for waterways listed below.)
River below Kentucky Lake	**0.0**	**22.4**	
Kentucky Lake	**22.4**	**206.7**	
Lower Kentucky Lake	22.4	145.0	
Jonathon Creek	0.0	6.3	
Blood River	0.0	8.8	
Big Sandy River	0.0	15.0	
Duck River	0.0	19.4	
Beech River	0.0	15.0	
Upper Kentucky Lake	145.0	206.7	

3.2 Listing and Definition of Activities

Reservoir releases are defined as the discharge of water through a hydroelectric plant or spillway gates. On the Cumberland and Tennessee Rivers the most frequent purposes of reservoir releases are for hydropower production or creation/maintenance of flood storage capacity. Under drought or emergency conditions (such as a grounded vessel) a reservoir release may be rarely used to provide minimum navigation depth. Although this has been done on the Tennessee and other rivers there is no record of increased flows having been used for this purpose on the Cumberland River. As noted above, the Nashville District has primary responsibility for operation, maintenance, and management of the multi-purpose projects for the purposes of hydropower, flood control, water supply, fish and wildlife, navigation, and recreation although not all lakes are operated to fulfill all of these functions. For example, Wolf Creek Dam and Lake Cumberland is operated for hydropower, flood control, water supply, fish and wildlife, and recreation, but is not directly concerned with navigation, although water released from Wolf Creek does incidentally contribute to the water used for navigation. The lakes are necessarily operated as a single system. Wolf Creek supplies between 60% and 70% of the water in the Cumberland during the course of a normal year.

Working through each of the project purposes, i.e., navigation, hydropower, flood damage reduction, water supply, fish and wildlife management, and recreation, we can draw the following conclusions.

As previously noted, Wolf Creek has no direct authority to support navigation. The impacts of navigation on threatened or endangered species has been thoroughly covered in the *Biological Assessment Operation and Maintenance of the Tennessee and Cumberland Rivers Navigation Systems.* The mainstem lakes are always maintained at certain lake levels to ensure adequate depths for navigation. As a result they show relatively little fluctuation. Although Wolf Creek's releases make some contribution to navigation as a by-product of its releases, particularly on the lower Ohio and Mississippi Rivers, lowering the Lake Cumberland pool would not have a direct impact on navigation, nor would it cause an appreciable change in the pool levels of any of the mainstem lakes. Navigation is not, therefore, a consideration for this BA.

Lake Cumberland has a number of municipal and industrial water intakes. It is estimated that 75 to 80 percent of the water withdrawn is eventually returned to the Cumberland River system. Water allocated for water supplies is considered to be low in the lake and the volumes withdrawn have little impact on the overall lake levels. Municipal and industrial water withdrawals are relatively small in comparison to the volume of the system. Municipal water supply, therefore, is not a consideration for this BA.

All of the lakes are operated with recreation in mind. Cordell Hull, Barkley, and Kentucky Lakes enjoy increased water depths (about a five foot increase) during the summer months to enhance recreational activities. Wolf Creek differs from the mainstem lakes in that it was designed for flood damage reduction and hydropower generation. It typically has a winter pool elevation of between 685 and 690. Late winter and spring rains are captured and retained to reduce flooding downstream and to store the water for later use. Usually Lake Cumberland is allowed to fill to elevation 723 by the Fourth of July. This is done in part with recreational enhancement in mind, but primarily to allow peaking hydropower generation during the summer when power demands are greatest and to supply fresh water to sustain water quality in the mainstem lakes. Recreation is not the determining factor in establishing Lake Cumberland's elevations and, therefore, has little direct effect on any species of concern. Recreation, therefore, is not a consideration for this BA.

Wolf Creek was designed and is operated for flood damage reduction. Typically flood waters are captured and retained in Lake Cumberland until they can be released safely downstream. This has little or no impact on the species in question although it may occasionally benefit some of them as it reduces particularly violent scouring of the streambed and banks. As Lake Cumberland is being operated at lowered level while the dam is repaired, then whatever water flows into the lake is being immediately released. This essentially mimics what would have been the natural flow had the dam never been built and should not unduly impact any species of concern. Flood damage reduction is not, therefore, a consideration for this BA.

Wolf Creek was designed and is operated for hydropower production. It produces hydropower from stored water in the lake and hydropower is the preferred method for regulating the lake level. The power pool is between elevations 673 and 723. Water from Wolf Creek's generation is also used by the mainstem lakes to produce power. Hydropower generation has caused fish and wildlife losses in the past by scouring the river beds with pulsed flows and then suddenly cutting off flows. However, hydropower production is not the primary cause of the overall losses. It is anticipated that while repairs on the dam are effected, hydropower will continue to be the primary method of maintaining the levels. Reducing the lake level in Lake Cumberland would not affect the impacts of the hydropower generation by the mainstem lakes, except possibly the timing of their releases. That is, the same volume of water would be passed to the mainstem lakes for their uses, but rather than retaining it for release during the summer when flows are typically lower, the releases would be made immediately as the water flowed into Lake Cumberland, mainly during the late winter and spring months. Hydropower, therefore, is not a consideration for this BA.

Water quality is a complex and difficult problem at Corps lakes. Although the dams themselves do not cause pollution, they do contribute to the problems. Lake Cumberland is much deeper than the original Cumberland River. The riverine ecology above the dam was drowned out and converted to a lacustrian ecology. Unable to move, mussels that once existed there were extirpated. The long retention time of Lake Cumberland has greatly reduced the water temperatures. In the tailwater below Wolf Creek the warm water fishery was forced out by the new cold water regime to the extent that the Cumberland River has been classified as a trout stream. Nutrients entering the lake are held long enough for bacterial action to virtually eliminate dissolved oxygen (DO) at certain times of the year. Mussels in the Wolf Creek tailwater are too cold to successfully reproduce and their host fish may no longer present in any case. Hydropower discharges during the summer months had very low DO and in recent years the Corps has been experimenting with discharging water through the sluice gates to provide both minimum flow and adequate DO. As Wolf Creek is operated at a reduced level or flatline regime, there will be less cold water storage. Water releases may be warmer than experienced under the current operating guide curves. There would also be less water available during the summer months for mitigating water quality issues in the mainstem lakes. Lower flows in the mainstem lakes would translate to longer retention times, which, in turn, usually result in decreased water quality and increased stress on aquatic organisms. As Wolf Creek contributes about 60% to 70% of the total water in the Cumberland River, the reduction in water quality and increase in stress to aquatics caused by changes in Center Hills operations is significant.

Lake Cumberland and the mainstem lakes are operated with fish and wildlife in mind. Examples include trying to maintain level pools during fish spawning periods, committing to minimum flow releases, and discharging water through the sluice gates to maintain adequate oxygen levels in the tailwaters. Whenever another authorized project purpose has the potential to negatively impact fish or wildlife resources, every effort is made to avoid or mitigate the impacts.

Working under the concept of focusing down from the broadest possible scope, a list was compiled of all authorized project purposes as they relate to the water passing through and released by Wolf Creek Dam. As can be seen from the discussion above, the only significant impact Wolf Creek can have on endangered species is through its impact on water quality and the methods chosen to manage and mitigate for fish and wildlife

3.3 Screening of Activities and Species

A complete list was compiled of all Federally listed species recorded in the counties that include or touch the Kentucky, Barkley, Cheatham, Old Hickory, Cordell Hull, and Cumberland Lakes, and the lower Tennessee and Cumberland Rivers below Kentucky and Barkley Lakes (see Table 2). This consisted of 42 species. Then the activities and species were each assessed on a case-by-case basis to determine if changes to water quality caused by the lowering of Center Hill's pool could affect that species. The results of this assessment were then plotted in a matrix (see Table 3). Working through the list, species that would not be affected by changes resulting from altering Center Hill's lake level (for example glade species such as Stones River bladderpod) were noted as "No Effect". Thirty-five species were eliminated from discussion in this way. The remaining 7 species which were determined to potentially be disturbed were noted as "May Affect, But Not Likely to Adversely Affect".

4.0 Individual Activity/Species Impacts

The following is an assessment of possible impacts of implementing reduced lake levels on Lake Cumberland on each species selected for evaluation, in light of best available information and professional judgment. Each discussion begins with a summary of the species account for the species under consideration.

Scientific Name	Common Name	Status	Class	County
Alasmidonta atropurpurea	Cumberland Elktoe	LE	Bivalvia	Pulaski
Apios priceana	Price's Potato-bean	LT	Magnoliopsida	Stewart, Montgomery, Davidson, Wayne, DeKalb
Arabis perstellata	Braun's Rockcress	LE	Magnoliopsida	Davidson, Wilson
Astragalus bibullatus	Pyne's Ground-plum	LE	Magnoliopsida	Davidson
Charadrius melodus	Piping Plover	LE	Aves	CALLOWAY, MARSHALL
Cumberlandia monodonta	Spectaclecase	C	Bivalvia	Smith, Hardin, Decatur, Humphreys, DeKalb
Cyprogenia stegaria	Fanshell	LE	Bivalvia	MARSHALL
Dalea foliosa	Leafy Prairie-clover	LE	Magnoliopsida	Davidson, Wilson, Sumner
Dromus dromas	Dromedary Pearlymussel	LE	Bivalvia	Trousdale, Putnam, DeKalb, Smith
Echinacea tennesseensis	Tennessee Coneflower	LE	Magnoliopsida	Davidson, Wilson
Epioblasma brevidens	Cumberlandian Combshell	LE	Bivalvia	Davidson, Putnam, DeKalb, Smith, Trousdale, Wilson
Epioblasma capsaeformis	Oyster Mussel	LE	Bivalvia	Smith, Putnam, DeKalb
Epioblasma florentina walkeri	Tan Riffleshell	LE	Bivalvia	Davidson
Epioblasma obliquata obliquata	Catspaw or Purple Cat's Paw	LE	Bivalvia	Wilson, Trousdale, Smith
Etheostoma boschungi	Slackwater Darter	LT	Actinopterygii	Wayne
Hemistena lata	Cracking Pearlymussel	LE	Bivalvia	Wayne, Hardin
Lampsilis abrupta	Pink Mucket	LE	Bivalvia	Stewart, Wilson, Hardin, Hardin, Decatur, Humphreys, Smith, DeKalb, Putnam, Benton, Trousdale, MARSHALL
Lesquerella globosa	Short's Bladderpod	C	Magnoliopsida	Montgomery, Cheatham, Davidson, Trousdale, Smith
Lesquerella perforata	Spring Creek Bladderpod	LE	Magnoliopsida	Wilson
Lexingtonia dolabelloides	Slabside Pearlymussel	C	Bivalvia	Humphreys
Myotis grisescens	Gray Bat	LE	Mammalia	Stewart, Houston, Hardin, Montgomery, Cheatham, Sumner, Wilson, Smith, DeKalb, Putnam, White, Warren, Benton, Perry, Decatur, Wayne, CALLOWAY, TRIGG
Myotis sodalis	Indiana Bat	LE	Mammalia	Stewart, Montgomery, White, Warren, Perry, CALLOWAY, TRIGG
Notropis albizonatus	Palezone Shiner	LE	Actinopterygii	Cumberland
Noturus stanauli	Pygmy Madtom	LE	Actinopterygii	Humphreys
Obovaria retusa	Ring Pink	LE	Bivalvia	Smith, Benton, Humphreys, Perry, Decatur, Hardin, MARSHALL, TRIGG
Orconectes shoupi	Nashville Crayfish	LE	Malacostraca	Davidson
Pegias fabula	Littlewing Pearlymussel	LE	LE	Pulaski
Phoxinus cumberlandensis	Blackside Dace	LT	Actinopterygii	Pulaski
Plethobasus cicatricosus	White Wartyback	LE	Bivalvia	Smith, Hardin, DeKalb, Perry, Decatur
Plethobasus cooperianus	Orange-foot Pimpleback	LE	Bivalvia	Smith, Hardin, Decatur, Perry, Humphreys, MARSHALL, TRIGG
Pleurobema clava	Clubshell	LE	Bivalvia	Smith, DeKalb, Hardin, Humphreys, Putnam
Pleurobema plenum	Rough Pigtoe	LE	Bivalvia	Trousdale, Smith, Hardin, Decatur, Humphreys
Pseudanophthalmus colemanensis	A Cave Obligate Beetle	C	Insecta	Montgomery
Pseudanophthalmus fowlerae	Fowler's Cave Beetle	C	Insecta	Clay
Pseudanophthalmus inquisitor	Searcher Cave Beetle	C	Insecta	Clay
Pseudanophthalmus insularis	Baker Station Cave Beetle	C	Insecta	Davidson
Ptychobranchus subtentum	Fluted Kidneyshell	C	Bivalvia	Pulaski
Quadrula sparsa	Appalachian Monkeyface	LE	Bivalvia	Trousdale
Sterna antillarum athalassos	Interior Least Tern	LE	Aves	MARSHALL
Villosa trabalis	Cumberland Bean	LE	Bivalvia	Clay

4.1 Birds. Two Federally listed species of birds were identified within the potential area of impacts. These were the piping plover (*Charadrius melodus*) and the interior least tern (*Sterna antillarum athalassos*). The only identified possible effects of lowering the Lake Cumberland pool were decreased water quality in the form of low DO and higher temperatures. Neither low DO nor higher temperatures would affect these species, nor would it significantly affect their food sources. A No Effect determination has therefore been reached for the piping plover and interior least tern.

4.2 Mammals.

4.2.1 Gray Bat (*Myotis grisescens*)

4.2.1.1 Species Account Summary. Gray bats are considered a wide-ranging species, and are known from suitable caves over virtually the entire Cumberland and Tennessee navigation systems. The species was Federally listed as Endangered in 1976. Populations are considered stable and have increased across portions of its range. Gray bat colonies are residents exclusively of limestone caves or cave-like habitats, and migrate seasonally between maternity and hibernating caves. During the summer, the colonies are segregated into maternity caves and bachelor caves. Gray bats are highly selective concerning caves, and consequently as few as nine hibernating caves may house roughly 95 percent of the population. Flying insects that have an aquatic life cycle make up the majority of food consumed by gray bats. Consequently, gray bats feed primarily along reservoirs, streams and riparian habitats, particularly above aquatic macrophyte beds. Concentration of large numbers of gray bats into a relatively small number of caves makes the species particularly vulnerable to instances of habitat disturbance. Human intrusions into maternity caves causing young to perish and into hibernating caves causing individuals to starve are thought to be primarily responsible for the species decline. Other factors attributed to threatening the species are pesticide poisoning, reduction of insect prey because of stream degradation, and flooding of caves by impoundment or natural causes.

4.2.1.2 Effects. None of the factors implicated in the decline of the Indiana bat have any readily apparent relationship to poor water quality. A slight decrease in water quality in the form of increased temperatures and lowered DO would not affect the gray bat, nor would it significantly affect their food sources. One potential cause for concern is if previously submerged cave openings become exposed and are used by the bats. This is considered unlikely because even though the Corps will be trying to maintain the lake at specific pool elevations, experience has shown that large rain events can raise the lake levels radically within a 24 to 48 hour period. The bats are unlikely to roost in caves they know will be subject to flooding. Nevertheless, the Corps commits to surveying the exposed shoreline for any caves that appear to be suitable for occupation. If caves are found the Corps will consult with the U.S. Fish and Wildlife Service to determine the best method of relocating or excluding bats from the cave. In this way any potential entrapment of bats would be avoided.

4.2.1.3 Cumulative Affects. There are no known future state, tribal, local, or private actions that are reasonably certain to occur in the action area and that would combine with navigation, water supply, recreation, flood damage reduction, hydropower, fish and wildlife, or water quality issues related to lowering the lake level of Center Hill Lake for cumulative effects on the gray bat .

4.2.1.4 Determination. Based on the information above, a No Effect determination has been reached for the gray bat.

4.2.2 Indiana Bat (Myotis sodalis)

4.2.2.1 Species Account Summary. The Indiana bat is medium sized in comparison with the gray bat, and closely resembles the little brown bat (*Myotis lucifugus*), except for coloration (U.S. Fish and Wildlife Service, 1991c). The Indiana bat generally has a body less than 2 inches long and a wingspread of approximately 10 inches. Coloration is a dull grayish chestnut, and the basal portion of the hairs of the back is a dull lead color. The calcar (heel of the foot) has a strong keel or flap of skin. The species was Federally listed as Endangered in 1967, and, although important protections are in place, populations have continued to decline. Although the species ranges throughout most of the eastern portion of the United States, hibernating colonies are known only from Indiana, Missouri, and Kentucky where approximately 87 percent of the population hibernate in only 7 limestone caves. The Indiana bat has rigid requirements for temperature and relative humidity in hibernating caves, hence the high concentration of individuals hibernating in a few caves. During the summer Indiana bats have been found in limestone caves and cave-like habitats under bridges and in old buildings and maternity colonies may be found under loose bark and in the hollows of trees. Bats forage at a height of 7 to 98 feet; they feed primarily on moths and aquatic insects. Indiana bats may forage up to 3.1 miles from their roost site. Roost trees generally have exfoliating bark, which allows the bat to roost between the bark and bole of the tree. Cavities and crevices in trees may also be used for roosting. In addition to having exfoliating bark, roost trees must be of sufficient diameter. Preferred trees are nine inches in diameter at breast height (dbh), or larger. Bachelor males have been found in trees with loose bark as small as 3 inches dbh. Small numbers of Indiana bats have been recorded within 1 mile of six Tennessee and Cumberland River navigation projects; Pickwick, Wheeler, Guntersville, Barkley, and Nickajack (Tennessee Valley Authority, 2003). The bat's diet consists of insects and it forages through riparian and floodplain trees. The decline of the species is attributed to commercialization of roosting caves, activities changing the climate of hibernacula caves, destruction by vandals, disturbances by increasing numbers of spelunkers and bat banding programs, use as laboratory animals, and potential insecticide poisoning.

4.2.2.2 Effects. None of the factors implicated in the decline of the Indiana bat have any readily apparent relationship to poor water quality. A slight decrease in water quality in the form of increased temperatures and lowered DO is the only impact identified that would occur throughout the study area in which the Indiana bat is likely to be found. This decreased water quality would not affect the Indiana bat, nor would it significantly affect their food sources. One potential cause for concern is if previously submerged cave openings become exposed and are used by the bats. This is considered unlikely because even though the Corps will be trying to maintain the lake at specific pool elevations, experience has shown that large rain events can raise the lake levels radically within a 24 to 48 hour period. The bats are unlikely to roost in caves they know will be subject to flooding. Nevertheless, the Corps commits to surveying the exposed shoreline for any caves that appear to be suitable for occupation. If caves are found the Corps will consult with the U.S. Fish and Wildlife Service to determine the best method of relocating or excluding bats from the cave. In this way any potential entrapment of bats would be avoided.

4.2.2.3 Cumulative Affects. There are no known future state, tribal, local, or private actions that are reasonably certain to occur in the action area and that would combine with navigation, water supply, recreation, flood damage reduction, hydropower, fish and wildlife, or water quality issues related to lowering the lake level of Center Hill Lake for cumulative effects on the Indiana bat .

4.2.2.4 Determination. Based on the information above, a No Effect determination has been reached for the Indiana bat.

4.3 Insects. Four Federally listed species of cave obligate beetles reside within the potential area of impacts. These species are the Cave Obligate Beetle (*Pseudanophthalmus colemanensis*), Fowler's Cave Beetle (*Pseudanophthalmus fowlerae*), the Searcher Cave Beetle (*Pseudanophthalmus inquisitor*), and the Baker Station Cave Beetle (*Pseudanophthalmus insularis*). The only identified possible effects of lowering the Lake Cumberland pool were decreased water quality in the form of low DO and higher temperatures. Neither low DO nor higher temperatures would affect these species. A No Effect determination has therefore been reached for all of the cave beetles.

4.4 Terrestrial Plants. Eight Federally listed species of terrestrial plants may be found within the potential area of impacts. These species are Price's potato-bean (*Apios priceana*), Braun's rock-cress (*Arabis perstellata*), Pyne's (Guthrie's) ground-plum (*Astragalus bibullatus*), Cumberland rosemary (*Conradina verticillata*), leafy prairie-clover (*Dalea foliosa*), Tennessee coneflower (*Echinacea tennesseensis*), Short's bladderpod (*Lesquerella globosa*), and the Spring Creek bladderpod (*Lesquerella perforata*). The only identified possible effects of lowering the Lake Cumberland pool were decreased water quality in the form of low DO and higher temperatures. Neither low DO nor higher temperatures would affect these species. A No Effect determination has therefore been reached for all of the terrestrial plants.

4.5 Crustaceans

4.5.1 Nashville Crayfish (*Orconectes shoupi*)

4.5.1.1 Species Account Summary. This species is currently known to exist only in the Mill Creek basin in Davidson and Williamson Counties. Tennessee. The species is threatened by siltation, stream alterations, and general water quality deterioration resulting from development pressures in the urbanized areas surrounding Xashvi1le. Tennessee. The species' limited distribution also makes it vulnerable to a single catastrophic event, such as a toxic chemical spill or other contamination. The Nashville crayfish, which attains a length of over 6 inches (15 centimeters], has been observed to inhabit pools and riffle areas with moderate current. Very little is known concerning the species' biology, but, like related crayfish, it probably feeds on vegetation fragments and animal matter. Reproduction occurs in the winter months, and females have been observed carrying eggs in the spring. The species' restricted range makes it vulnerable to toxic chemical spills. The species is also subjected to water quality and other habitat deterioration associated with urban runoff, land disturbance, and development within the Mill Creek watershed.

4.5.1.2 Effects. The Nashville crayfish is only found in Mill Creek in the pool and riffle areas, i.e., above the Cheatham Lake pool. As such, it would not be disturbed by any of the possible effects of lowering Lake Cumberland.

4.5.1.3 Cumulative effects. There are no known future state, tribal, local, or private actions that are reasonably certain to occur in the action area and that would combine with navigation, water supply, recreation, flood damage reduction, hydropower, fish and wildlife, or water quality issues related to lowering the lake level of Lake Cumberland for cumulative effects on the Nashville Crayfish. A flood control project being planned for the Mill Creek basin by the U.S. Army Corps of Engineers-(COE) could also impact the species, but separate consultation will be pursued, as appropriate for the feasibility study.

4.5.1.4 Determination. Based on the information above, a No Effect determination has been reached for the Nashville Crayfish.

4.6 Fish

4.6.1 Slackwater Darter (*Etheostoma boschungi*)

4.6.1.1 Species Account Summary. The area occupied by the slackwater darter is the Highland Rim of the Nashville Basin. Presently it occupies headwater streams arising from the highlands of Lawrence and Wayne counties, Tennessee. The darter is not known from the Elk River, the largest tributary in the south bend of the Tennessee River. However, the Elk interposes the Buffalo and Flint rivers, two streams where slackwater darters are found. They are also absent from Bear Creek, the largest north-flowing tributary. The slackwater darters occur in two distinctly different, but necessarily adjacent, habitats: non-breeding and breeding habitats. The two distinctly different habitats must be adjacent; that is, the fish must be able to swim from stream to spawning area and vice versa. The species typically inhabits gentle riffles and slackwater areas of small to medium-sized shallow, upland tributary streams no more than 40ft wide and less than 7ft deep (Williams and Robinson 1980). Breeding sites are usually 30-45cm above the adjacent streams, and therefore depend on heavy rains to raise the stream level and allow the darters access to the sites. Breeding site substrates are characterized by Lee cherty silt loams, Lobelville cherty loam, and Staffell, Bodine and Etowah silt loams. At these sites the water is usually about 4-8cm deep and flows slowly into an adjacent stream.

Slackwater darter populations are affected by any factor that negatively influences their habitat, both breeding and non-breeding habitat. Increased development has caused erosion and draining of areas with shallow groundwater limiting slackwater darter breeding habitat. Farming and cattle are the principal industries surrounding the darter's habitat, which has exposed darter habitat to pesticides, herbicides, fertilizers, and stockyard runoff. Other threats include degradation of surface and groundwater caused by the intrusion of toxins and industrial and domestic wastes from sewage lines and septic tank seepage. The slackwater darters are also threatened by predation from the green sunfish, *Lepomis cyanellus,* and the pirate perch, *Aphredoderus sayanus*.

Since breeding sites are located above the stream level any factor that limits accessibility to the sites would be detrimental to the darter population. Factors would include those listed under "Past Threats" with the inclusion of a drought.

4.6.1.2 Effects. The slackwater darter is not found in the Cumberland River or any of its tributaries. Its inclusion in this BA is based on its presence in streams tributary to Kentucky Lake. As noted above, the species typically inhabits gentle riffles and slackwater areas of small to medium-sized shallow, upland tributary streams no more than 40ft wide and less than 7ft deep, i.e., it would not be found in Kentucky Lake itself. None of the possible effects of lowering Lake Cumberland would affect the water quality in the Kentucky Lake tributaries.

4.6.1.3 Cumulative effects. There are no known future state, tribal, local, or private actions that are reasonably certain to occur in the action area and that would combine with navigation, water supply, recreation, flood damage reduction, hydropower, fish and wildlife, or water quality issues related to lowering the lake level of Lake Cumberland for cumulative effects on the slackwater darter.

4.6.1.4 Determination. Based on the information above, a No Effect determination has been reached for the slackwater darter.

4.6.2 Palezone Shiner (*Notropis albizonatus*)

4.6.2.1 Species Account Summary. The palezone shiner is a member of the Cyprinidae family. The species grows to a maximum of 2 inches. The species' food habits are unknown. The palezone shiner has been taken from the Paint Rock River (PRR), Jackson County, Alabama; the Little South Fork of the Cumberland River (LSFCR), Wayne and McCreary Counties, Kentucky; Marrowbone Creek, Cumberland County, Kentucky; and Cover Creek, Clinch River drainage, Campbell County, Tennessee (Starnes and Etnier 1980; Warren and Burr 1990; Richard Hannan, Kentucky State Nature Preserves Commission, *in litt*., 1990). It currently occurs in only two widely disjunct populations in the Paint Rock River in Jackson County, Alabama, and the Little South Fork of the Cumberland River in Wayne and McCreary Counties, Kentucky.

The palezone shiner occurs in large creeks and small rivers in the Tennessee and Cumberland River systems. The species inhabits flowing pools and runs of upland streams that have permanent flow; clean, clear water; and substrates of bedrock, cobble, pebble, and gravel mixed with clean sand (Starnes and Etnier 1980, Branson and Schuster 1982, Burr and Warren 1986, Ramsey 1986).

Three of the four known localities for the palezone shiner (except Marrowbone Creek) and both extant populations (Paint Rock River and the Little South Fork of the Cumberland River) occur in streams on the periphery of the Cumberland Plateau. The distribution of the palezone shiner implies that the two remaining populations are remnants of a once more widespread distribution (Starnes and Etnier 1986). Thus, two alternate, but not mutually exclusive, explanations may be relevant concerning the highly fragmented range of the palezone shiner: (1) the species is relatively ancient and extirpation has occurred prehistorically over much of its range, or (2) the extirpation of populations over much of the range has occurred in historic times as a result of loss or degradation of appropriate habitat from siltation, inadequate in-stream flow, reservoir construction, channelization, and coal-mining runoff (Warren and Burr 1990). Since about 1980, the lower third of Little South Fork of the Cumberland River (about 15 River Miles) has been periodically subjected to toxic surface mine runoff (especially, elevated heavy metal concentrations) that all but eliminated the mussel fauna from the lower third of the river (Anderson 1989).

4.6.2.2 Effects. The palezone shiner is not found in the Cumberland River or any of its tributaries except the Big South Fork where it no longer occurs in the lower third of the river. Its inclusion in this BA is based on its presence in streams tributary to Lake Cumberland. Its known locations, therefore, are above the possible area of effect.

4.6.2.3 Cumulative effects. There are no known future state, tribal, local, or private actions that are reasonably certain to occur in the action area and that would combine with navigation, water supply, recreation, flood damage reduction, hydropower, fish and wildlife, or water quality issues related to lowering the lake level of Lake Cumberland for cumulative effects on the palezone shiner.

4.6.2.4 Determination. Based on the information above, a No Effect determination has been reached for the palezone shiner.

4.6.3 Blackside Dace (*Phoxinus cumberlandensis*)

4.6.3.1 Species Account Summary. The blackside dace is member of Cyprinidae family. It is a small fish, less than 3 inches, and has a single black lateral stripe, a green/gold back with black specks, and a pale or sometimes brilliant scarlet belly. The blackside dace feeds in schools of 5 to 20 individuals grazing on rocks, on sandy substrate, and beneath stream banks among root hairs and brush (Starnes 1981).

Historically, this fish likely inhabited many small cool-water streams in the upper Cumberland River system in southeastern Kentucky and northeastern Tennessee. However, this species is now restricted to short stream reaches (an estimated total of 14 stream miles) in 30 streams. This species occupies streams in both public and private property along the upper Cumberland River drainage (primarily above Cumberland Falls) in Pulaski, Laurel, McCreary, Whitley, Knox, Bell, Harlan, and Letcher Counties, Kentucky; and Scott, Campbell, and Claiborne Counties, Tennessee; where it inhabits small (7-15 ft wide) upland streams with moderate flows.

4.6.3.2 Effects. The blackside dace is found only in short reaches of upland streams with moderate flows. It is not found in the Cumberland River or any of the impounded lakes. Its inclusion in this BA is based on its presence in streams tributary to Lake Cumberland. Its known locations, therefore, are above the possible area of effect.

4.6.3.3 Cumulative effects. There are no known future state, tribal, local, or private actions that are reasonably certain to occur in the action area and that would combine with navigation, water supply, recreation, flood damage reduction, hydropower, fish and wildlife, or water quality issues related to lowering the lake level of Lake Cumberland for cumulative effects on the blackside dace.

4.6.3.4 Determination. Based on the information above, a No Effect determination has been reached for the blackside dace.

4.6.4 Pygmy Madtom (*Noturus stanauli*)

4.6.4.1 Species Account Summary. The pygmy madtom is a member of the Ictaluridae family. This species is the smallest of the known madtoms reaching a maximum length of 1.5 inches (Etnier and Jenkins 1980). The average life span of most madtoms is 2 or 3 years. Etnier and Jenkins (1980) noted that only two age groups were evident in collections of the species, indicating a life span of 1+ years. Madtoms almost exclusively prey on aquatic insect larvae. Most authors have suggested that they are primarily opportunistic feeders and take prey items in proportion to their abundance (Starnes and Starnes 1985, Gutowski and Stauffer 1990).

Much of the species' life history is unknown. However, much can be inferred from comparisons with closely related species. Related madtoms nest in cavities beneath slabrocks and at times use other cover objects, such as cans and bottles. As native mussels are abundant in pygmy madtom habitat, it is possible that this species might use empty mussel shells for nesting cover. Reproduction likely occurs from spring to early summer; smoky madtom and least madtom reproduction occurs between late May and mid-July (Dinkins and Shute 1993).

The species has been collected from only two short river reaches separated by about 600 river miles (Etnier and Jenkins 1980, O'Bara 1991). It has been taken from the Duck River, Humphreys, and Hickman Counties, Tennessee; and from the Clinch River, Hancock County, Tennessee. In 1993, three pygmy madtoms were taken in the Duck River, Hickman County (Saylor, Tennessee Valley Authority, *in litt*., 1993). Etnier and Jenkins (1980), in their description of this species, reported that it had been taken in only about one-half of the collections made at the Clinch River and only about one-fourth of the collection at the Duck River site.

Pygmy madtoms occur in moderate to large rivers, in shallow shoals where the current is moderate to strong, and there is pea-sized gravel or fine sand substrates. Although there are no observations of seasonal habitat shifts, the closely related smoky madtom is known to switch from riffles to overwinter in shallow pools (Dinkins 1984). Many individuals are also found in the flowing portions of pools during the reproductive season (Dinkins and Shute 1993). The Duck River where the species has historically been taken is being seriously threatened by stream bank erosion. The runoff from large urban areas has degraded water and substrate quality.

As the two known populations are isolated from each other by impoundments, recolonization of any extirpated population would not be possible without human intervention. The absence of natural gene flow among populations of these fishes leaves the long-term genetic viability of these isolated populations in question.

Additionally, several madtom species have, for unexplained reasons, been extirpated from portions of their range. Etnier and Jenkins (1980) speculated that this may "...in addition to visible habitat degradation be related to their being unable to cope with olfactory 'noise' being added to riverine ecosystems in the form of a wide variety of complex organic chemicals that may occur only in trace amounts." If madtoms are adversely impacted by increased concentrations of complex organic chemicals, an increase in the presence of these materials could be a problem for the pygmy madtom.

4.6.4.2 Effects. The pygmy madtom was included in this BA because one of their two known populations occurs in the Duck River, a tributary of Kentucky Lake. Because this population is in a tributary area and therefore upstream of any possible effects of any possible influence by the proposed lowering of Lake Cumberland it is unlikely that the pygmy madtom could be affected in any way.

4.6.4.3 Cumulative effects. There are no known future state, tribal, local, or private actions that are reasonably certain to occur in the action area and that would combine with navigation, water supply, recreation, flood damage reduction, hydropower, fish and wildlife, or water quality issues related to lowering the lake level of Lake Cumberland for cumulative effects on the pygmy madtom.

4.6.4.4 Determination. Based on the information above, a No Effect determination has been reached for the pygmy madtom.

4.7 Mussels

Parmalee and Bogan (1998) provided a brief synopsis on unionoid faunal provinces of North America, which is summarized in this section. Approximately one-third of the nearly 1000 freshwater mussels species in the world have been recorded in North America. Through taxonomic studies, mussel surveys, and collection, it was recognized that the freshwater mussel species within North America congregated in distinct geographic regions termed unionoid faunal provinces. Boundaries were marked by the river systems they drained, and the mussel fauna that was endemic within each province. Approximately 45 mussel species that were historically confined to the Cumberland and Tennessee River drainages were called Cumberlandian species. Species included in this Biological Assessment; the Dromedary pearlymussel (*Dromus dromas*, Lea, 1834), Cumberlandian combshell (*Epioblasma brevidens*, Lea, 1834), and Oyster mussel (*Epiobasma capsaeformis*, Lea, 1834) are Cumberlandian mussels. The Cumberlandian province nests within the Mississippi River drainage basin that is known as the Interior Basin (Mississippian) province. Mussel species recorded in this region were historically widely distributed. Other species included in this Biological Assessment; the Fanshell (*Cyprogenia stegaria*), Pink mucket (*Lampsilis abrupta*), Cracking pearlymussel (*Hemistena lata*), White wartyback (*Plethobasus cicatricosus*), Orangefoot pimpleback (*Plethobasus cooperianus*), Clubshell (*Pleurobema clava*), and the Rough pigtoe (*Pleurobema plenum*) are species that were historically found in the Interior Basin province. Presently, the mussel fauna in the Nashville District reflect a blend of species represented in these two unionoid faunal provinces. Cumberlandian mussels tend to be somewhat confined to the Tennessee and Cumberland River systems, however species from the broader Interior Basin have been able to spread into and colonize a large portion of the Cumberlandian province.

Impoundments result in the dramatic modification of riffle and shoal habitats and the resulting loss of mussel resources, especially in larger rivers. Impoundment impacts are most profound in riffle and shoal areas, which harbor the largest assemblages of mussel species. Dams interrupt most of a river's ecological processes by modifying flood pulses; controlling impounded water elevations; altering water flow, sediments, nutrients, energy inputs and outputs; increasing depth; decreasing habitat heterogeneity; and decreasing stability due to subsequent sedimentation. The reproductive process of riverine mussels is generally disrupted by impoundments making mussels unable to successfully reproduce and recruit under reservoir conditions.

In addition, dams can also seriously alter downstream water quality and riverine habitat, and negatively impact tailwater mussel populations. These changes include thermal alterations immediately below dams; changes in channel characteristics, habitat availability, and flow regime; daily discharge fluctuations; increased silt loads; and altered host fish communities. Coldwater releases from large non-navigational dams and scouring of the river bed from highly fluctuating, turbulent tailwater flows have also been implicated in the demise of mussel faunas.

Population losses due to impoundments have probably contributed more to the decline of the mussels and other Cumberlandian Region mussels than any other single factor. Contaminants contained in point and non-point discharges can degrade water and substrate quality and adversely impact mussel populations. The effects are especially profound on juvenile mussels, which can readily ingest contaminants, and glochidia, which appear to be very sensitive to certain toxicants. Mussels are very intolerant of heavy metals, and even at low levels, certain heavy metals may inhibit glochidial attachment to fish hosts.

Water pollution over historic times has been a slow but widespread process often attributed to poor land use practices. Water quality degradation included siltation, sediment contamination, excessive nutrient, fertilizer, and urban runoff, as well as point and nonpoint source pollution. Siltation is the largest single pollutant, affecting over 4,800 miles of streams. Siltation fills navigation channels, increasing the need for maintenance dredging and disposal (TN 305(b) Report, 2002). Point and nonpoint Source pollution control are implemented by non-Corps agencies.

Exploitation has affected all mussel populations. Native Americans used them for food and tools; however decimation of large mussel beds resulted from pearl collecting, the pearl button industry, and most recently, the cultured pearl industry. As commercial size mussels decline, there is the potential for over harvesting and illegal take. Currently, however, a marked decline in the cultured pearl industry has greatly reduced the market demand for freshwater mussel shells. It is unknown when and if the market demand will reverse.

Natural predation is a concern for remnant mussel populations. Muskrats (*Ondatra zibethicus*) prey upon adult and sub-adult mussels while crayfish, fish, and other invertebrates prey upon the juvenile mussels. Exotic invasive aquatic species pose additional threats. Asiatic Clams (*Corbicula fluminea*) and Zebra mussels (*Dreissena polymorpha*) compete with native freshwater mussels. Zebra mussels pose the greatest threat because of their ability to colonize on native mussels. Attachment on to any waterborne vessel or boat trailer has facilitated the spread of these mussels.

Commercial sand and gravel dredging is a regulated activity that permanently removes sand, gravel, and benthic organisms from the river bottom. Secondary impacts include a localized temporary increase in turbidity and a change in the river bottom topography. Sand and gravel extraction creates underwater holes and furrows tens of feet deeper than the natural river bottom elevation. Permitting helps protect mussel beds by confining extraction to disturbed areas to reduce the likelihood of encountering mussels.

Current threats to the species listed above are not totally understood (USFWS, 1985) but are predominantly anthropic in nature. The activities are under the authority of varying federal, state, local, and private entities.

Water levels are regulated on the Cumberland and Tennessee Rivers by the Corps and TVA respectively to maintain the minimum 9-foot channel depth and, under emergency conditions, to rescue grounded barges. Water level regulation for these purposes may be accomplished by holding pool levels, by releases from one navigation project to another, or by a combination of both. The result is a kind of minimum flow, or, at least, avoidance of dewatering some mussel habitat outside the channel as could occur in absence of the navigation purpose. Riverine conditions found below dams provide refugia for mussel populations in the over bank and back chutes of islands. Mussel sanctuaries have been established below several locks and dams by state natural resource agencies. In summation, this feature may positively affect listed species by maintaining a status quo of existing populations.

While not a direct result of Corps O&M activities, zebra mussels were introduced into the inland waterways via bilge water from commercial vessels and have spread quickly throughout the inland navigation system and other water bodies by attaching to both commercial and recreational vessels. Zebra mussels affect native mussel species at all ages. Filtering water containing glochidia reduces recruitment. Attaching to juvenile and adult mussels impairs growth, reproduction, and survival if the mussel is unable to open to feed, breath, or reproduce. The loss of all ages indirectly results in lower population densities. The Corps and TVA have evaluated control of zebra mussels and related species at their facilities (U. S. Army Corps of Engineers, Nashville District and Tennessee Valley Authority, 1992). The Corps found that implementing control of Zebra mussels and related species at its facilities would have no affect on listed mussel species, but that an increase in zebra mussel populations, independent of Corps activities, could have a profoundly negative impact on native mussels. Since that time, Corps observations are that the expected zebra mussel population explosion has not materialized and that, instead, populations seem to have waned somewhat. Zebra mussel control measures are still “on the shelf” should they be needed, but the nexus of any invasion may be more toward recreational navigation – i.e. with or without commercial navigation and O&M activities, zebra mussels may continue to spread. Long-term impact to the viability of freshwater mussel communities is unknown.

Cumulative impacts to the aquatic environment from non-federal actions have additionally contributed to the decline, endangerment or extinction of many mussel species in the last century. The direct destruction of species or habitat and the indirect impact of degrading habitat and water quality, though individually minor, have collectively resulted in significant cumulative actions.

As the human population increases, human threats to the remaining populations of freshwater mussels will continue to grow. Urbanization and the need for water supply, wastewater treatment, waterborne recreation and mineral extraction are expected to increase with future development. Permits for a host of activities (bridge construction, utility crossings, diffusion pipe outfalls, etc.) that potentially affect mussels, will continue to be requested. Secondary impacts may include urban runoff, sedimentation, water pollution, sediment contamination, clean water scarcity, additional marinas, spills, and the spread of exotics. These activities may combine to adversely affect mussels. On the other hand, regulatory programs primarily aimed at improving water quality (Total Maximum Daily Load, NPDES, Stormwater Pollution Prevention Permits, etc) will be beneficial to mussels. With or without O&M activities, increased human-related changes in the watershed are expected to continue and likely to increase in the future. Whether existing and future conservation and regulatory programs will prevent these changes from translating to increased impacts on mussels remains to be seen.

4.7.1 Cumberland Elktoe (*Alasmidonta atropurpurea*)

4.7.1.1 Species Account Summary. The Cumberland elktoe (*Alasmidonta atropurpurea*) has a thin but not fragile shell. The shell's surface is smooth, somewhat shiny, and covered with greenish rays. Young specimens have a yellowish brown shell, and the shells of adults are generally black. The inside of the shell is shiny with a white, bluish white, or sometimes peach or salmon color. The Cumberland elktoe is endemic to the Cumberland River system in Tennessee and Kentucky and is considered endangered in the State of Kentucky (Kentucky State Nature Preserves Commission (KSNPC) 1991). Historic records exist from the Cumberland River and from its tributaries entering from the south between the Big South Fork Cumberland River upstream to Cumberland Falls. Specimens have also been taken from Marsh Creek above Cumberland Falls. Old records of a related species, *Alasmidonta marginata,* exist from other creeks above Cumberland Falls; and there is speculation that these specimens were probably the Cumberland elktoe (Gordon 1991). Because the area above the falls has been severely impacted by coal mining, any populations of *A. atropurpurea* that might have existed there were likely lost (Gordon 1991). Presently, three populations of the Cumberland elktoe are known to persist. The species survives in the middle sections of Rock Creek, McCreary County, Kentucky; the upper portions of the Big South Fork Cumberland River basin in McCreary County, Kentucky; and Scott, Fentress, and Morgan counties, Tennessee; and in Marsh Creek, McCreary County, Kentucky (Gordon 1991). Any Cumberland elktoe populations that may have existed in the main stem of the Cumberland River were likely lost when Wolf Creek Dam was completed. Other tributary populations were likely lost due to the impacts of coal mining, pollution, and spills from oil wells. The upper Big South Fork basin population is threatened by coal mining runoff and could also be threatened by impoundments. The

Marsh Creek population has been adversely affected and is still threatened by potential spills from oil wells. The Rock Creek population could be threatened by logging. All three populations, especially Rock Creek and Marsh Creek, are restricted to such short stream reaches that they could be eliminated by naturally occurring events such as toxic chemical spills

4.7.1.2 Effects. None of the known populations of the Cumberland elktoe exist within the possible area of effect of lowering Lake Cumberland. It is therefore unlikely that the Cumberland elktoe could be affected in any way.

4.7.1.3 Cumulative effects. The impact of Lake Cumberland on the Cumberland River System is significant. Normally 60% to 70% of the water in the Cumberland River flows from Wolf Creek Dam. In the interest of public safety and to relieve pressure on the foundation of Wolf Creek Dam, Lake Cumberland has been lowered. At the same time, the Corps is contemplating lowering Center Hill Lake for needed repairs to that dam. Flows from Wolf Creek Dam are significantly lower than what the public has become accustomed to. Anticipated cumulative effects include significantly changed and reduced water quality for all reaches below Wolf Creek Dam including lower DO, increased water temperatures, and lessened dilution of pollutants.

4.7.1.4 Determination. Based on the information above, a No Effect determination has been reached for the Cumberland elktoe.

4.7.2 Spectaclecase (*Cumberlandia monodonta*)

4.7.2.1 Species Account Summary. The spectaclecase, a candidate species, is a large mussel that reaches at least 9.25 inches in length. As a group, mussels are extremely long-lived, particularly among the margaritiferids (e.g., eastern pearlshell, *Margaritifera margaritifera*, up to 200 years [Mutvei et al. 1994]; Louisiana pearlshell, *M. hembeli*, up to 75 years [Johnson and Brown 1998]). Baird (2000) aged 278 specimens of the spectaclecase in Missouri by sectioning the hinge ligament. The maximum age he determined was 56 years, but he surmised that some large individuals may have been older. A very large specimen (9.25 inches) from the St. Croix River, Minnesota and Wisconsin, was estimated (qualitatively based on external growth rings counts) to be aged at approximately 70 years (Havlik 1994).

Hermaphroditism may occur in the spectaclecase (van der Schalie 1966), although it is not generally reported in the literature, nor from Baird’s (2000) life history study in Missouri. Another margaritiferid, the eastern pearlshell, has been shown to produce glochidia hermaphroditically (Bauer 1987). This reproductive mechanism, which is thought to be rare in dense populations, may be implemented when populations exhibit low densities and high dispersion levels. Females changing to hermaphrodites may be an adaptive response (Bauer 1987) assuring that a recruitment class may not be lost in small populations. If hermaphroditism does occur in the spectaclecase, it may explain the occurrence of small, but persistent populations (e.g., in cold tailwaters receiving hypolimnetic discharges from large dams [Gordon and Layzer 1989]).

The spectaclecase occurs in large rivers and is a habitat-specialist, relative to other mussel species. Baird (2000) noted its occurrence on outside river bends below bluff lines. It most often inhabits riverine microhabitats that are sheltered from the main force of current. Utterback's (1915) record of this species in the Northwest Missouri Lakes is puzzling but may refer to seasonally flooded oxbow lakes along the Missouri River. It occurs in substrates from mud and sand to gravel, cobble, and boulders in relatively shallow riffles and shoals with slow to swift current (Buchanan 1980, Parmalee and Bogan 1998, Baird 2000). According to Stansbery (1967), the spectaclecase is usually found in firm mud between large rocks in quiet water very near the interface with swift currents. Specimens also have been reported in tree stumps, root masses, and in beds of rooted vegetation (Stansbery 1967, Oesch 1984). Similar to other margaritiferids, spectaclecase tend to be aggregated (Gordon and Layzer 1989), particularly under slab boulders or bedrock shelves (Call 1900, Hinkley 1906, Buchanan 1980, Parmalee and Bogan 1998, Baird 2000) where they are protected from the current. Up to 200 specimens have been reported from under a single large slab in the Tennessee River at Muscle Shoals (Hinkley 1906). Unlike most species that move about to some degree, the spectaclecase may seldom, if ever, move except to burrow deeper; they may die from stranding during droughts (Oesch 1984).

The spectaclecase was considered as extant if live or fresh-dead specimens have been collected since the mid-1980s. Extant populations of the spectaclecase are known from 20 streams in 10 states and three Service regions. These include the Cumberland River system (Caney Fork) and the Tennessee River system (Tennessee River, Clinch, Nolichucky, Duck Rivers).

The decline of the spectaclecase is primarily the result of habitat loss and degradation (Neves 1991). These losses have been documented well since the mid-19th century (Higgins 1858). Chief among the causes of decline are impoundments, channelization, chemical contaminants, mining, and sedimentation (Williams et al. 1993; Neves 1991, 1993; Neves et al. 1997; Watters 2000)

Population losses due to impoundments have probably contributed more to the decline and imperilment of the spectaclecase than any other factor. Dams impound large river habitats throughout almost the entire range of the species. These impoundments have left short and isolated patches of remnant habitat, typically just downstream of the dams. Dams impound most of the Tennessee and Cumberland Rivers and many of their tributaries; these systems were once strongholds for the spectaclecase (Ortmann 1924).

Dams either impound or alter the temperature regimes of approximately 90 percent of the 562-mile length of the Cumberland River downstream of Cumberland Falls. Other major U.S. Army Corps of Engineers (Corps) impoundments on Cumberland River tributaries (e.g., Stones River, Caney Fork) have inundated an additional 100 miles or more of riverine habitat for the spectaclecase. Coldwater releases from Wolf Creek, Dale Hollow (Obey River), and Center Hill (Caney Fork) Dams continue to affect adversely riverine habitat for the spectaclecase in the Cumberland River system. One-third of the streams that the spectaclecase historically occupied are in the Tennessee and Cumberland River systems.

The effects of contaminants are especially profound on juvenile mussels (Robison et al. 1996), which readily ingest contaminants adsorbed to sediment particles while feeding, and on glochidia, which appear to be very sensitive to toxicants (Goudreau et al. 1993, Jacobson et al. 1997). Mussels are very intolerant of heavy metals (Keller and Zam 1991, Havlik and Marking 1987), and even at low levels, certain heavy metals may inhibit glochidial attachment to fish hosts (Huebner and Pynnönen 1992). Cadmium appears to be the heavy metal most toxic to mussels (Havlik and Marking 1987), although chromium, copper, mercury, and zinc also adversely affect biological processes (Naimo 1995, Keller and Zam 1991, Jacobson et al. 1997, Keller and Lydy 1997). Bogan and Parmalee (1983) considered the spectaclecase "apparently...unable to survive even minimal amounts of organic pollution or chemical waste."

4.7.2.2 Effects. Although the spectaclecase may be still extant in the Caney Fork River, the water releases from Center Hill Dam are so cold as to preclude reproduction. The Caney Fork has been classified as a trout stream by the State of Tennessee and any attempt to intentionally warm the water above 20° C would require approval from the state's water board. It is unlikely that a remnant population still exists below Center Hill. Water releases from Wolf Creek would not affect water quality in the Caney Fork and would not, therefore, affect the spectaclecase there even if it does still exist there.

4.7.2.3 Cumulative Effects. There are no known future state, tribal, local, or private actions that are reasonably certain to occur in the action area and that would combine with navigation, water supply, recreation, flood damage reduction, hydropower, fish and wildlife, or water quality issues related to lowering the lake level of Lake Cumberland for cumulative effects on the spectaclecase.

4.7.2.4 Determination. Based on the information above, a No Effect determination has been reached for the spectaclecase.

4.7.3 Eastern Fanshell Pearly Mussel (*Cyprogenia stegaria*)

4.7.3.1. Species Account Summary. The fanshell is a medium-sized (reaching up to approximately 80 mm in length) freshwater mussel with light green or yellow with green mottling or rays (USFWS 2003). Like other freshwater mussels, the fanshell feeds by filtering food particles from the water column.

The reproductive cycle of the fanshell is similar to that of other native freshwater mussels. Recent induced infestations of glochidia on nine of sixteen fish species tested indicate that the following species are suitable hosts: mottled sculpin (*Cottus bairdi*), banded sculpin (*Cottus carolinae*), greenside darter (*Etheostoma blennioides*), snubnose darter (*Etheostoma simoterum*), banded darter (*Etheostoma zonale*), tangerine darter (*Percina aurantiaca*), blotchside logperch (*Percina burtoni*), logperch *(Percina caprodes*), and Roanoke darter (*Percina roanoka*) (Jones and Neves 2000).

The fanshell has undergone a substantial range reduction. It was historically distributed in the Ohio, Wabash, Cumberland, And Tennessee Rivers and their larger tributaries in Pennsylvania, Ohio, West Virginia, Illinois, Indiana, Kentucky, Tennessee, Alabama, and Virginia (Johnson 1980, KSNPC 1980, Ahlstedt 1986, Bates and Dennis 1985, Lauritsen 1987, Cummings et al. 1987 and 1988, Starnes and Bogan 1988, USFWS 1991). It is believed that reproducing populations are now present in only three rivers, the Clinch River (Hancock County, TN and Scott County, VA), the Green River (Hart and Edmonson Counties, KY), and the Licking River (Kenton, Campbell, and Pendleton Counties, KY). In addition, based on collections of a few older individuals in the 1980s, small remnant (apparently nonreproducing) populations may still persist in the Cumberland River.

The fanshell inhabits medium to large rivers (Bates and Dennis 1985). It has been reported primarily from relatively deep water in gravelly substrate with moderate current (Gordon and Layzer 1989). The loss of many historic populations was likely due to the impacts of impoundments, navigation projects, water quality degradation, and other forms of habitat alteration, including gravel and sand dredging, that directly affected the species and reduced or eliminated its fish host(s) (USFWS 1991). Incidental take of the fanshell where it is co-located with commercially harvested mussel beds is also attributed to its decline (USFWS 1990, 1991).

Most fanshell populations are small and are geographically isolated from one another. It is likely that many of the remaining populations are now small enough that they can no longer maintain long-term genetic viability (Soule

1980). Other current threats to freshwater mussels are well documented in the general mussel description.

4.7.3.2 Effects. The fanshell is likely to still exist in the upper reaches of Old Hickory Lake on the Cumberland River, although it no longer appears to be a reproducing population. Water quality is a concern for this species. If Lake Cumberland does not store and release its customary volumes of water during the summer months, all aquatic species downstream from Wolf Creek Dam could incur additional stress. This would mimic to some extent what would occur in a natural system during low summer flows. Stressors would primarily be in the form of lowered DO and increased temperatures, but would also include less dilution of pollutants being discharged into the river. For pollution intolerant species such as the fanshell this could be particularly important. Under current conditions it is a virtual certainty that the population will eventually be extirpated because the mussels are unable to reproduce in the cold water. It is possible that if the water temperatures increase sufficiently the mussels could revive from their cold induced torpor and reproduce. In the unlikely event that this did occur, this would be considered a positive occurrence.

4.7.3.3 Cumulative effects. The impact of Lake Cumberland on the Cumberland River System is significant. Normally 60% to 70% of the water in the Cumberland River flows from Wolf Creek Dam. In the interest of public safety and to relieve pressure on the foundation of Wolf Creek Dam, Lake Cumberland has been lowered. At the same time, the Corps is contemplating lowering Center Hill Lake for needed repairs to that dam. Flows from Wolf Creek Dam are significantly lower than what the public has become accustomed to. Anticipated cumulative effects include significantly changed and reduced water quality for all reaches below Wolf Creek Dam including lower DO, increased water temperatures, and lessened dilution of pollutants.

4.7.3.4 Determination. Based on the information above, a May Effect, but Not Likely to Adversely Affect determination has been reached for the Cumberlandian combshell.

4.7.4 Dromedary Pearlymussel (*Dromus dromas*)

4.7.4.1 Species Account Summary. The dromedary pearlymussel is a medium-sized (reaching up to 90 mm in length) freshwater mussel with a yellowish green shell with two sets of broken green rays. The life span of the species is greater than 50 years (USFWS 1984, VFWIS 2003). Like other freshwater mussels, the dromedary pearlymussel feeds by filtering food particles from the water column.

The reproductive cycle of the dromedary pearlymussel is similar to that of other native freshwater mussels. Recent studies have identified the fantail darter (*Etheostoma flabellare*) as a glochidial host for the dromedary pearlymussel. Laboratory studies also identified the following potential host species: the banded darter (*Etheostoma zonale*), tangerine darter (*Percina aurantiaca*), logperch (*Percina caprodes*), and gilt darter (*Percina evides*) (Watson and Neves 1998). Jones and Neves (2001) recently confirmed the suitability of the banded darter, tangerine darter, and logperch and identified the following additional glochidial host species: black sculpin (*Cottus baileyi*), greenside darter (*Etheostoma blennioides*), snubnose darter (*Etheostoma simoterum*), blotchside logperch (*Percina burtoni*), channel darter (*Percina copelandi*), and Roanoke darter (*Percina roanoka*).

This species was historically widespread in the Cumberland and Tennessee River systems (Bogan and Parmalee 1983). It was last collected from Mussel Shoals, an 85 km reach of the Tennessee River in Alabama, prior to 1931 (van der Schalie 1939) and is presumed to be extirpated from the shoal. The species survives at a few shoals in the Powell and Clinch Rivers in Tennessee and Virginia, and possibly in the Cumberland River in Tennessee (USFWS 1984, Neves 1991). Nine occurrences of the species were recorded during a 1980 survey by Virginia Tech and the Tennessee Valley Authority; however, the dromedary pearlymussel is currently believed to be reduced to only three reproducing populations (NatureServe 2003).

The dromedary pearlymussel inhabits small to medium, low turbidity, high to moderate gradient streams. The species is commonly found near riffles on sand and gravel substrates with stable rubble (USFWS 1984). Though commonly associated with shallow, high velocity riffles and shoals, individuals have been found in deeper (up to 18 feet in depth), slower waters (USFWS 1984).

Many of the historic populations of the dromedary pearlymussel were apparently lost when the river sections they inhabited were impounded. Over 50 impoundments on the Tennessee and Cumberland Rivers have eliminated the majority of riverine habitat for the species in its historic range (ESIS 1996, USFWS 1984). The Powell River and upper tributaries of the Clinch River, in particular, are also subject to sediment and particulate matter loading from coal mining activities (Stansbery 1973). Other threats that are attributed to population declines are similar to those described in the general mussel description.

4.7.4.2 Effects. The dromedary pearlymussel was once found in the Cumberland River system. The current species listing by the Tennessee Natural Heritage Program lists it as possibly still surviving in Trousdale, Putnam, DeKalb, and Smith counties. Water quality is a concern for this species. If Lake Cumberland does not store and release its customary volumes of water during the summer months, all aquatic species downstream from Wolf Creek Dam could incur additional stress. This would mimic to some extent what would occur in a natural system during low summer flows. Stressors would primarily be in the form of lowered DO and increased temperatures, but would also include less dilution of pollutants being discharged into the river. If the water regime becomes warmer due to the reduced flows, the mussels may find it easier to reproduce. From this standpoint reduced flows may prove beneficial to the dromedary pearlymussel.

4.7.4.3 Cumulative effects. The impact of Lake Cumberland on the Cumberland River System is significant. Normally 60% to 70% of the water in the Cumberland River flows from Wolf Creek Dam. In the interest of public safety and to relieve pressure on the foundation of Wolf Creek Dam, Lake Cumberland has been lowered. At the same time, the Corps is contemplating lowering Center Hill Lake for needed repairs to that dam. Flows from Wolf Creek Dam are significantly lower than what the public has become accustomed to. Anticipated cumulative effects include significantly changed and reduced water quality for all reaches below Wolf Creek Dam including lower DO, increased water temperatures, and lessened dilution of pollutants.

4.7.4.4 Determination. Based on the information above, a May Effect, but Not Likely to Adversely Affect determination has been reached for the dromedary pearlymussel.

4.7.5 Cumberlandian Combshell (*Epioblasma brevidens*)

4.7.5.1 Species Account Summary. The Cumberlandian combshell has a thick solid shell with a smooth to clothlike periostracum, which is yellow to tawny brown in color with narrow green broken rays. The nacre is white. The shells of females are inflated, with serrated teethlike structures along a portion of the shell margin. See Johnson (1978) and Parmalee and Bogan (1998) for a more complete description of the species and Parmalee and Bogan (1998) for a synonymy of the species. Gordon (1991) provided diagnostic characters.

Spawning in the lampsiline Cumberlandian combshell occurs in late summer (Gordon 1991). Females display until the water temperature drops below approximately 50°F in the fall, burrow into the substrate to overwinter, and begin displaying again as early as March (Jones, pers. comm., 2003). Gravid females, qualitatively estimated at 8 to 13 years of age, have been reported from early May to June at water temperatures of 59.0° to 64.0°F (Ahlstedt 1991a, Yeager and Saylor 1995). The female has a complex mantle display that resembles the cercae of insect larvae (e.g., stoneflies) protruding from under two or three small stones (Jones, pers. comm., 2003). One of its host fishes, the logperch (*Percina caprodes*), has the peculiar habit of flipping small stones in search of food (Etnier and Starnes 1993). Glochidial release generally is complete by mid-June (Jones, pers. comm., 2002). Several other native host fish species have been identified, including the wounded darter, redline darter, bluebreast darter, snubnose darter (*E. simoterum*), greenside darter (*E. blennioides*), banded sculpin, black sculpin, and mottled sculpin (Yeager and Saylor 1995; Jones and Neves, unpub. data). Transformation took from 16 to 48 days, at 60.4° to 62.4°F (Yeager and Saylor 1995).

The Cumberlandian combshell was described from the Cumberland River in Tennessee, possibly from Davidson County (Nashville). Historically, it ranged throughout the Cumberlandian Region, occurring in three physiographic provinces (i.e., Interior Low Plateau, Cumberland Plateau, Ridge and Valley) and five states (i.e., Alabama, Kentucky, Mississippi, Tennessee, Virginia). In the Cumberland River it occurred from the base of Cumberland Falls, McCreary and Whitley Counties, Kentucky, downstream to Stewart County, Tennessee. In the Tennessee River, it occurred throughout the main stem, downstream to Benton and Humphreys Counties, Tennessee. The Cumberlandian combshell also occurred in numerous tributaries in the Cumberland and Tennessee River systems. The most downstream records in both rivers are from archeological sites (Parmalee and Bogan 1998), indicating that at least in premodern times this species occurred further downstream from the area strictly defined as the Cumberlandian Region.

The Cumberlandian combshell has been extirpated from a large percentage of its former range. Mainstem populations in both the Cumberland and Tennessee Rivers are now considered extirpated (Ahlstedt, pers. comm., 2003). This species has also apparently been eliminated from numerous tributaries in the Cumberland River system (e.g., Rockcastle River, Beaver Creek, Obey River, Caney Fork, Stones River, Red River) and the Tennessee River system (e.g., Station Creek, Wallen Creek, Holston River, Nolichucky River, West Prong Little Pigeon River, Little Tennessee River, Paint Rock River, Elk River, Little Bear Creek, Cedar Creek, Duck River). The Cumberlandian combshell has also been extirpated from large portions of additional tributaries in the Cumberlandian Region (e.g., Clinch River, Powell River, North Fork Holston River, Bear Creek).

Extant Cumberland River system populations occur in Buck Creek, Pulaski County, Kentucky; and Big South Fork, Scott County, Tennessee, and McCreary County, Kentucky (Table 3, USFWS 2003). In the Tennessee River system, populations are thought to remain in the Clinch River, Scott County, Virginia, and Hancock County, Tennessee; Powell River, Lee County, Virginia, and Claiborne and Hancock Counties, Tennessee; and Bear Creek, Colbert County, Alabama, and Tishimingo County, Mississippi (Table 3, USFWS 2003). Although the species was found in Alabama in Cedar Creek (tributary to Bear Creek) in 1988, a recent survey of the entire Bear Creek system failed to reveal even shells of the Cumberlandian combshell at nine sites in Cedar Creek (McGregor and Garner, in press).

The Big South Fork population is sizable and recruiting (Ahlstedt, pers. comm., 2003). Recent evidence of recruitment has also been detected in the Powell River (Jones, letter dated June 9, 2003), but populations in other stream reaches are small and of questionable long-term viability (e.g., Buck Creek, Bear Creek) (Wolcott and Neves 1994, Hagman 2000, McGregor and Garner, in press; Ahlstedt, pers. comm., 2003).

This species inhabits medium-sized streams to large rivers on shoals and riffles in coarse sand, gravel, cobble, and boulders (Dennis 1985, Gordon 1991). It is not associated with small stream habitats (Dennis 1985) and tends not to extend as far upstream in tributaries. In general, it occurs in larger tributaries than does its congener the oyster mussel (*Epioblasma capsaeformis)*. Gordon (1991) states that the species prefers depths less than 3 feet, but it appears to persist in the deep-water areas of the Old Hickory Reservoir on the Cumberland River, where there is still fairly strong flow from the Cordell Hull and Center Hill Reservoirs (Gordon and Layzer 1989).

The abundance and distribution of the Cumberlandian combshell decreased historically from human-induced habitat loss and degradation (Williams et al. 1993, Neves 1993) caused by impoundments (e.g., TVA impoundments on the Cumberland and Tennessee Rivers and their tributaries, Laurel River, Obey River, Caney Fork, Stones River), sedimentation and turbidity, channelization, and contaminants contained in numerous point and nonpoint sources. A comprehensive review of these past threats is provided elsewhere (USFWS 2003, Williams et al. 1993, Neves 1993, Neves 1991, Neves et al. 1997, Watters 2000, Richter et al. 1997). These habitat changes have resulted in significant extirpations (localized loss of populations), restricted and fragmented distributions, and poor recruitment of young. Numerous Cumberlandian Region streams have experienced mussel kills from toxic chemical spills and other causes (Cairns et al. 1971, Crossman et al. 1973, Neves 1986, Wolcott and Neves 1994). The Cumberlandian combshell and its habitat is currently being impacted by excessive sediment bed loads of smaller sediment particles, changes in turbidity, increased suspended solids (primarily resulting from nonpoint-source loading from poor land-use practices and lack of, or maintenance of, best management practices [BMPs], and pesticides (USFWS 2003, Williams et al. 1993, Neves 1993, Neves 1991, Neves et al. 1997, Watters 2000, Richter et al. 1997). Other primarily localized impacts include coal mining, gravel mining, reduced water quality below dams, developmental activities, water withdrawal, impoundments, and alien species. Their restricted ranges and low population levels also increase their vulnerability to toxic chemical spills and the deleterious effects of genetic isolation.

Although the dams of the Cumberland and Tennessee Rivers themselves probably contributed more to the destruction of riverine habitat for the

Cumberlandian combshell, channel maintenance activities continue to cause substrate instability and alteration in these rivers and may serve to diminish what habitat remains for the recovery of these species. Impacts associated with coal mining activities have particularly altered upper Cumberland River system streams with diverse historical mussel faunas (Stansbery 1969, Blankenship 1971, Blankenship and Crockett 1972, Starnes and Starnes 1980, Schuster et al. 1989, Anderson et al. 1991) and have been implicated in the decline of *Epioblasma* species, especially in the Big South Fork (Neel and Allen 1964). Strip mining continues to threaten mussels in coal field drainages of the Cumberland Plateau (Anderson 1989, Warren et al. 1999) with increased sedimentation loads and acid mine drainage, including Cumberlandian combshell populations.

4.7.5.2 Effects. The dromedary pearlymussel was once found in the Cumberland River system and appears to persist in the deep-water areas of the Old Hickory Reservoir on the Cumberland River, where there is still fairly strong flow from the Cordell Hull and Center Hill Reservoirs. It may also be found in Buck Creek and in the Big South Fork, but above the possible influence of Lake Cumberland's pool levels. Water quality is a concern for this species. If Lake Cumberland does not store and release its customary volumes of water during the summer months, all aquatic species downstream from Wolf Creek Dam could incur some slight additional stress. This would mimic to some extent what would occur in a natural system during low summer flows. Stressors would primarily be in the form of lowered DO and increased temperatures, but would also include less dilution of pollutants being discharged into the river. For pollution intolerant species such as the fanshell this could be particularly important, however, the increase of stressors would not likely be significant.

4.7.5.3 Cumulative effects. The impact of Lake Cumberland on the Cumberland River System is significant. Normally 60% to 70% of the water in the Cumberland River flows from Wolf Creek Dam. In the interest of public safety and to relieve pressure on the foundation of Wolf Creek Dam, Lake Cumberland has been lowered. At the same time, the Corps is contemplating lowering Center Hill Lake for needed repairs to that dam. Flows from Wolf Creek Dam are significantly lower than what the public has become accustomed to. Anticipated cumulative effects include significantly changed and reduced water quality for all reaches below Wolf Creek Dam including lower DO, increased water temperatures, and lessened dilution of pollutants.

4.7.5.4 Determination. Based on the information above, a May Effect, but Not Likely to Adversely Affect determination has been reached for the Cumberlandian combshell.

4.7.6 Oyster Mussel (*Epioblasma capsaeformis*)

4.7.6.1 Species Account Summary. According to Parmalee and Bogan (1998), adult oyster mussels can reach lengths of up to 7.0 cm (2.8 inches). The Duck River population achieves nearly twice the size of specimens from other populations. Like other freshwater mussels, the oyster mussel feeds by filtering food particles from the water column.

The reproductive cycle of the oyster mussel is similar to that of other native freshwater mussels. The oyster mussel was one of the most widely distributed Cumberlandian mussel species, with historical records existing from six states (Alabama, Georgia, Kentucky, North Carolina, Tennessee, and Virginia). This mussel is now only extant in a handful of stream and river reaches in four States in the Tennessee and Cumberland River systems, including the Duck River, Maury and Marshall Counties, Tennessee; Powell River, Claiborne and Hancock Counties, Tennessee, and Lee County, Virginia; Clinch River, Hancock County, Tennessee, and Scott, Russell, and Tazewell Counties, Virginia; Nolichucky River, Hamblen and Cocke Counties, Tennessee; and Big South Fork of the Cumberland River, McCreary County, Kentucky, and Scott County, Tennessee (Wolcott and Neves 1990; Ahlstedt 1991; Bakaletz 1991; Gordon 1991; Ahlstedt and Tuberville 1997; S.A. Ahlstedt, pers. comm. 2002; Service 2003).

Oyster mussels typically occur in sand and gravel substrate in streams ranging from medium-sized creeks to large rivers (Gordon 1991; Parmalee and Bogan 1998). They apparently prefer shallow riffles and shoals and have been found associated with water willow (*Justicia americana*) beds (Ortmann 1924; Gordon 1991; Parmalee and Bogan 1998). Oyster mussels have been found in areas with coarse sand to boulder substratum and in pockets of gravel between bedrock ledges in areas of swift current (Neves 1991).

Reduction in range and population density of the oyster mussel have resulted from human-induced changes in stream and river channels, including channel modifications (e.g., dams, dredging, mining) and historic or episodic water pollution events (USFWS 2003). The entire length of the main stems of the Tennessee and Cumberland Rivers and many of their largest tributaries are now impounded or greatly modified by the discharge of tailwaters. Much of the oyster mussel’s historic range has been impounded by the Tennessee Valley Authority (TVA) and the U.S. Army Corps of Engineers (USFWS 1997). These impoundments permanently alter the free-flowing aquatic habitat required by the species and its glochidial host species (USFWS 2003).

Current threats to freshwater mussels are well documented. In addition, populations in free-flowing river sections below dams can be adversely affected or extirpated from reduced dissolved oxygen levels, unnatural flow regimes, and colder temperature, or greatly modified by the dams or their tailwater releases (Neves et al. 1997). The Duck River population could be lost if the proposed Columbia Dam is completed. Present populations are also threatened by adverse impacts of coal mining (USFWS 1997).

4.7.6.2 Effects. None of the known populations of the oyster mussel exist within the possible area of effect of lowering Lake Cumberland. It is therefore unlikely that the oyster mussel could be affected in any way.

4.7.6.3 Cumulative effects. There are no known future state, tribal, local, or private actions that are reasonably certain to occur in the action area and that would combine with navigation, water supply, recreation, flood damage reduction, hydropower, fish and wildlife, or water quality issues related to lowering the lake level of Lake Cumberland for cumulative effects on the spectaclecase.

4.7.6.4 Determination. Based on the information above, a No Effect determination has been reached for the oyster mussel.

4.7.7 Tan Riffleshell (*Epioblasma florentina walkeri*)

4.7.7.1 Species Account Summary. The tan riffleshell mussel is a medium-sized (7 cm) freshwater mussel with a brown to yellow colored shell with numerous green rays (NatureServe 2003). Like other freshwater mussels, the tan riffleshell feeds by filtering food particles from the water column.

The reproductive cycle of the tan riffleshell is similar to that of other native freshwater mussels. Laboratory studies indicate that at least five suitable glochidial host species exist for the tan riffleshell including the fantail darter (*Etheostoma flabellare*), greenside darter (*Etheostoma blennioides*), redline darter (*Etheostoma rufilineatum*), snubnose darter (*Etheostoma simoterum*) and banded sculpin (*Cottus bairdi*) or mottled sculpin (*Cottus carolinae*) (Rogers et al. 2001).

The tan riffleshell has been reported historically throughout Tennessee and southwestern Virginia in the Tennessee River system in the Duck River, Red River, Middle Fork Holston River, and Hiwassee River (USFWS 1984, Parmalee and Hughes 1994). The only known reproducing populations exist in Indian Creek, a tributary to the Clinch River (Tazewell County, VA) and the Big South Fork, a tributary to the Cumberland River, though individuals from non-viable populations have been recorded in the Clinch River, Middle Fork Holston River, and the Hiwassee River (Rogers 1999, Rogers et al. 2001). The tan riffleshell inhabits sand and gravel substrates and is usually found in headwaters, riffles and shoals (Bogan and Parmalee 1983, NatureServe

2003).

Threats that led to the decline of known populations at the time of the tan riffleshell's listing included water quality degradation resulting from mine acid and municipal wastes. In the Red River system, low dissolved oxygen levels and untreated wastewater from a meat packing facility contributed to the species decline. In addition, mercury and lead contamination in the middle fork of the Holston, low dissolved oxygen levels in the west fork Stones River, and a history of spills of fly ash and sulfuric acid and heavy metal contamination in the Clinch River are documented pollution concerns for these historic populations. Construction of the Tennessee Valley Authority Dam also extirpated remaining populations in the Duck River drainage. Infestation of tan riffleshell habitat by the Asiatic clam (*Corbicula fluminea*) is also believed to be a principal cause of the species decline (USFWS 1977).

The species' decline has resulted primarily from habitat and water quality deterioration caused by impoundments and by pollution and siltation resulting from mining, agriculture, and construction activities. Owing to the species' limited distribution, any factor that adversely modifies habitat or water quality in the short river reaches that the species inhabits could threaten its survival (USFWS 1988).

4.7.7.2 Effects. The only area listed within the study area where the tan riffleshell may still be extant is in the Stones River in Davidson County, Tennessee. This is upstream above the possible area of water quality impacts that could be caused by lowering Lake Cumberland's pool level.

4.7.7.3 Cumulative effects. There are no known future state, tribal, local, or private actions that are reasonably certain to occur in the action area and that would combine with navigation, water supply, recreation, flood damage reduction, hydropower, fish and wildlife, or water quality issues related to lowering the lake level of Lake Cumberland for cumulative effects on the tan riffleshell.

4.7.7.4 Determination. Based on the information above, a No Effect determination has been reached for the tan riffleshell.

4.7.8 Catspaw or Purple Cat's Paw (*Epioblasma obliquata obliquata*)

4.7.8.1 Species Account Summary. This freshwater mussel historically occurred in the Ohio River and its large tributaries in Ohio, Indiana, Illinois, Kentucky, Tennessee, and Alabama. Presently the purple cat's paw pearlymussel in known from only two relict, apparently nonreproducing populations. The distribution and reproductive capacity of this species have been seriously impacted by the construction of impoundments on the large rivers it once inhabited. Unless reproducing populations are found or methods developed to maintain existing populations, this species will likely become extinct in the foreseeable future.

The purple cat's paw, which is characterized as a large river species (Bates and Dennis 1985), has a medium-size shell that is subquadrate in outline (Bogan and Parmalee 1983). The shell has fine, faint, wavy green rays with a smooth and shiny surface. The inside of the shell is purplish to deep purple (the inside shell of the white cat's paw is white). Like other freshwater mussels, the purple cat's paw feeds by filtering food particles from the water. It has a complex reproductive cycle in which the mussel's larvae parasitize fish. The mussel's life span, fish species its larvae parasitize, and other aspects of its life history are unknown. The purple cat's paw pearlymussel was historically distributed in the Ohio, Cumberland, and Tennessee River systems in Ohio, Illinois, Indiana, Kentucky, Tennessee and Alabama (Bogan and Parmalee 1983, Isom, et al. 1979, Kentucky State Nature Preserves Commission 1980, Parmalee et al. 1980, Stansbery 1970, Watters 1986). Based on personal communications with knowledgeable experts (Steven Ahlstedt and John Jenkinson. Tennessee Valley Authority, 1987; Mark Gordon and Robert Anderson. Tennessee Technological University, 1988; Arthur Bogan, Philadelphia Academy of Sciences, 1988; Ronald Cicerello, Kentucky State Nature Preserves Commission, 1988; David Stansbery, Ohio State University, 1987) and a review of current literature, the species is known to survive in only two river reaches, but apparently as nonreproducing populations. These are located in the Cumberland River, Smith County. Tennessee, and the Green River, Warren and Butler Counties, Kentucky. The continued existence of these two populations is questionable. Unless reproducing populations can be found or methods can be developed to maintain these or create new populations, the species will become extinct in the foreseeable future. Any individuals that do still survive in these two river reaches are also threatened from other factors. The individuals still surviving in the Cumberland River are potentially threatened by gravel dredging, channel maintenance, and commercial mussel fishing. Although the species is not commercially valuable, incidental take of the species does sometimes occur in the Cumberland River during commercial mussel fishing for other species.

The purple cat's paw pearlymussel was recognized by the Service as a category 2 species (one that is being considered for possible addition to the Federal List of Endangered and Threatened Wildlife) in a May 22, 1984, notice published in the Federal Register (49FR 21664). On May 2, 1988, and September 8, 1988, the Service notified Federal, State, and local governmental agencies and interested individuals by mail that a status review was being conducted specifically on the purple cat's paw pearlymussel and that the species could be proposed for listing. On July 27, 1989, the Service published in the Federal Register (54FR 31209) a proposal to list the purple cat's paw pearlymussel as an endangered species. That proposal provided information on the species' biology, status, and threats to its continued existence.

4.7.8.2 Effects. The only area listed within the study area where the cat's paw may still be extant is in the Cumberland River in Smith County, Tennessee, although if it is still present it does not appear to be reproducing. Water quality is a concern for this species. If Lake Cumberland does not store and release its customary volumes of water during the summer months, all aquatic species downstream from Wolf Creek Dam could incur additional stress. This would mimic to some extent what would occur in a natural system during low summer flows. Stressors would primarily be in the form of lowered DO and increased temperatures, but would also include less dilution of pollutants being discharged into the river. Water quality is monitored at Cordell Hull Dam which is immediately upstream of the only potential population. When water quality becomes a concern water is passed through the spillway gates to ensure a maximum uptake of oxygen. Water quality in the Cordell Hull tailwater has not, therefore, become a significant concern. The increase of stressors at this location would likely be insignificant.

4.7.8.3 Cumulative effects. The impact of Lake Cumberland on the Cumberland River System is significant. Normally 60% to 70% of the water in the Cumberland River flows from Wolf Creek Dam. In the interest of public safety and to relieve pressure on the foundation of Wolf Creek Dam, Lake Cumberland has been lowered. At the same time, the Corps is contemplating lowering Center Hill Lake for needed repairs to that dam. Flows from Wolf Creek Dam are significantly lower than what the public has become accustomed to. Anticipated cumulative effects include significantly changed and reduced water quality for all reaches below Wolf Creek Dam including lower DO, increased water temperatures, and lessened dilution of pollutants.

4.7.8.4 Determination. Based on the information above, a May Effect, but Not Likely to Adversely Affect determination has been reached for the cat's paw.

4.7.9 Cracking Pearlymussel (*Hemistena lata*)

4.7.9.1 Species Account Summary. Detailed species descriptions can be found in Mirarchi et. al. (2004), Parmalee and Bogan (1998), and USFWS (1991d) therefore only a description summary based on these three references is provided here. The shells of mature Cracking pearlymussels are slightly inflated, thin but fairly strong (Parmalee and Bogan, 1998). The shells are elongated and elliptical to rhomboidal in outline with a rounded anterior margin and pointed to obliquely truncate posterior margin (Mirarchi et. al., 2004). The umbos are flattened and sculptured with a few strong ridges (Parmalee and Bogan, 1998). Shell color ranges from dull yellow, brownish-green, to brown (Parmalee and Bogan, 1998) and dark green broken rays are often found on the shell surface (USFWS, 1991d). The shells do not meet but gape along the anterior and posterior margins and the shell surface may be marked by uneven growth lines (Parmalee and Bogan, 1998). The nacre is pale bluish white with a dark purple umbo cavity and adults can reach up to 90 mm (3.5 inches) in diameter (Parmalee and Bogan, 1998). Cracking Pearlymussels are short-term brooders and glochidia have been observed in mid-May (Parmalee and Bogan, 1998). Jones and Neves (2000) collected females that were gravid from late April to late June and noted that the Whitetail shiner (*Cyprinella galactura*), Streamline chub (*Erimystax dissimilis*), Central stoneroller (*Campostoma anomalum*), and Banded sculpin (*Cottus carolinae*) could be possible hosts for this species.

The Cracking pearlymussel is widely distributed and is more numerous in medium sized rivers (Parmalee and Bogan, 1998). Historically it was found throughout the Ohio, Tennessee, and Cumberland River systems in Ohio, Indiana, Illinois, Kentucky, Tennessee, Alabama, and Virginia (USFWS, 1991d). These mussels are found deeply buried in substrate consisting of mud, sand, and fine gravel and usually occur in medium-sized rivers with moderate currents in less than 2 feet of water (Parmalee and Bogan, 1998). The Cracking pearlymussel was federally listed as and endangered species in 1989 and a recovery plan was written in 1991 (USFWS, 1989b, 1989c, 1991d). To date, critical habitat has not been designated for this species (TVA, 2003). In the Cumberland River watershed, this species was once found in the main stem of the Cumberland River from Clay County, Tennessee upstream to Pulaski County, Kentucky; and in the Big South Fork Cumberland River (Parmalee and Bogan, 1998). The Cracking pearlymussel is considered extirpated throughout much of its range and is thought to exist in a few reaches in the Clinch and Powell Rivers in Tennessee and Virginia, and possibly in the Green River, Kentucky (USFWS, 2001b). The Cracking pearlymussel occurs in Hancock, Lincoln, and Hardin Counties in Tennessee (TABS, 2002d). It survives below Pickwick and Wilson Dams on the Tennessee River, and between Fayetteville, Tennessee and Tims Ford Dam on the Elk River (TVA, 2003). In Alabama the Cracking Pearlymussel is extant only in the Elk River but in few numbers (Mirarchi et. al., 2004). In Kentucky, the Cracking pearlymussel may only exist in the upper Green River (KCWCS, 2005). The USFWS (2001b) plans to establish a nonessential experimental population (NEP) for 16 mussels, including the Cracking pearlymussel, below Wilson Dam in Colbert County, Alabama. This area is located between Tennessee River miles (TRM 259.4 - 246.0) and includes the lower 5 mile reaches of tributaries entering the Wilson Dam tailwaters (USFWS, 2001b) that, under Section 10(j) of the Endangered Species Act, cannot be designated as critical habitat for a NEP (USFWS, 2001b). The National Park Service (2003) plans to reintroduce the Cracking pearlymussel into the upper Cumberland River system in the Big South Fork National River and Recreational Area in Kentucky and Tennessee. The National Park Service (2003a) also plans to propagate and restore freshwater mussels in a reach of the Green River near Mammoth Cave Nation Park that is inhabited by seven federally endangered mussels including the Cracking pearlymussel.

4.7.9.2 Effects. This species was included in this BA because of its presence in the upper reaches of Kentucky Lake. Although Kentucky Lake is connected to the Cumberland River via an unregulated canal, the possible effects of lowering Center Hill's pool could not reach so far upstream on Kentucky Lake. The proposed action could not, therefore, affect this species.

4.7.9.3 Cumulative effects. There are no known future state, tribal, local, or private actions that are reasonably certain to occur in the action area and that would combine with navigation, water supply, recreation, flood damage reduction, hydropower, fish and wildlife, or water quality issues related to lowering the lake level of Lake Cumberland for cumulative effects on the Cracking Pearlymussel.

4.7.9.4 Determination. Based on the information above, a No Effect determination has been reached for the Cracking Pearlymussel.

4.7.10 Pink Mucket (*Lampsilis abrupta*)

4.7.10.1 Species Account Summary. Detailed species descriptions can be found in Parmalee and Bogan (1998) Mirarchi et. al. (2004) and the Endangered Species Information System (ESIS, 1996e) therefore only a description summary based on these three references is provided here. The shells of mature Pink muckets are relatively large, thick, heavy, inflated, and subovate to subquadrate in outline (ESIS, 1996e). The umbos are located in the anterior third of the shell and in young individuals they are marked with faint scarcely looped ridges (Parmalee and Bogan, 1998). The posterior shell margin in males is rounded to very bluntly pointed, while female shells are broadly rounded to truncate with values that often gap at the posterior margin especially in females (Mirarchi, et. al., 2004). The posterior ridge is prominent in males and is distinct along the dorsal margin (ESIS, 1996e). The shell surface is smooth and marked by uneven concentric growth lines (ESIS, 1996e). The exterior shell color varies from a light yellow in juveniles, to a yellowish brown or dark brown with occasional markings of broken fine to fairly wide dark green rays (Parmalee and Bogan, 1998). The nacre ranges from white to pink or salmon in color (Mirarchi et. al., 2004). Adults can grow up to 120 mm (4.75 in) in diameter (Parmalee and Bogan, 1998). Pink muckets are long-term brooders (Mirarchi et. al., 2004). Females become gravid in August and contain glochidia in September that are released the following June (Parmalee and Bogan, 1998). According to Mirarchi et. al. (2004), possible host fish for the Pink mucket include Largemouth bass (*Micropterus salmoides*), Smallmouth bass (*Micropterus dolomieu*), Spotted bass (*Micropterus punctulatus*) Sauger (*Stizostedion canadense*) and Freshwater drum (*Aplodinotus grunniens*).

The Pink mucket is a wide ranging Interior Basin species historically inhabiting the Mississippi, Ohio, Cumberland, and Tennessee Rivers (Parmalee and Bogan, 1998) in the states of Louisiana Arkansas, Missouri, Illinois, Indiana Ohio, Pennsylvania, West Virginia, Virginia, Kentucky, Tennessee, and Alabama (USFWS, 1997b). Pink muckets have been found in medium to large rivers, and riverine sections of impoundments (TVA, 2003). They have been collected in habitat ranging from silt to boulders, but the more typical habitat consists of cobble, gravel and sand with individuals found in water depths ranging from 0.8 to 8 m (2.6 – 26.2 feet) deep (ESIS, 1996e). The Pink Mucket was federally listed in 1976 and a recovery plan was written in 1985 (ESIS, 1996e). To date, critical habitat for this species has not been designated (TVA, 2003). According to TVA (2003), the pink mucket has been encountered within the last 30 years in nearly all the tailwaters of the mainstem Tennessee River dams and in parts of Bear Creek and the Clinch, French Broad, and Holston rivers, and although always uncommon or rare, old individuals have been found with a few more individuals found more often below Pickwick and Guntersville Dams. On the Cumberland River, populations tend to be localized with one of the larger populations occurring in the Carthage-Rome area in Smith County, Tennessee (Parmalee and Bogan, 1998). The most recently collected individuals in Tennessee are old adults or relicts of former populations and though the species is widely distributed, it is usually not abundant in the Cumberland and Tennessee Rivers (TABS, 2002h). The Pink mucket only occurs in the riverine reaches below Wilson and Guntersville Dams in Alabama where individuals less than ten years of age are reportedly rare (Mirarchi et. al., 2004). In Kentucky, Pink muckets sporadically occur in the upper Green River (KCWCS, 2005). According to the USFWS (1997b), new Pink mucket populations have been discovered in the Ohio River after an absence of 75 years. The Pink mucket is currently known in 16 rivers and tributaries from seven states (USDOE, 2003). The greatest concentrations are in the Tennessee (Tennessee, Alabama), Cumberland (Tennessee, Kentucky), Osage and Meramec Rivers (Missouri); with smaller numbers found in the Clinch (Tennessee); Green (Kentucky); Ohio (Illinois); Kanawha (West Virginia); Big Black, Little Black, and Gasconde (Missouri); and Current and Spring Rivers (Arkansas) (USDOE, 2003).

4.7.10.2 Effects. Water quality is a concern for this species. If Lake Cumberland does not store and release its customary volumes of water during the summer months, all aquatic species downstream from Wolf Creek Dam could incur additional stress. This would mimic to some extent what would occur in a natural system during low summer flows. Stressors would primarily be in the form of lowered DO and increased temperatures, but would also include less dilution of pollutants being discharged into the river. As noted above, the most recently collected individuals in Tennessee are old adults or relicts. The largest known population on the Cumberland is in the Carthage – Rome area in Smith County immediately downstream from

Cordell Hull Dam. Water quality is monitored at Cordell Hull Dam which is immediately upstream of the only potential population. When water quality becomes a concern water is passed through the spillway gates to ensure a maximum uptake of oxygen. Water quality in the Cordell Hull tailwater has not, therefore, become a significant concern. The increase of stressors at this location would likely be insignificant.

4.7.10.3 Cumulative effects. The impact of Lake Cumberland on the Cumberland River System is significant. Normally 60% to 70% of the water in the Cumberland River flows from Wolf Creek Dam. In the interest of public safety and to relieve pressure on the foundation of Wolf Creek Dam, Lake Cumberland has been lowered. At the same time, the Corps is contemplating lowering Center Hill Lake for needed repairs to that dam. Flows from Wolf Creek Dam are significantly lower than what the public has become accustomed to. Anticipated cumulative effects include significantly changed and reduced water quality for all reaches below Wolf Creek Dam including lower DO, increased water temperatures, and lessened dilution of pollutants.

4.7.10.4 Determination. Based on the information above, a May Effect, but Not Likely to Adversely Affect determination has been reached for the pink mucket.

4.7.11 Slabside Pearlymussel (*Lexingtonia dolabelloides*)

4.7.11.1 Species Account Summary. The slabside pearlymussel is primarily a large creek to moderately-sized river species, inhabiting sand, fine gravel, and cobble substrates in relatively shallow riffles and shoals with moderate current (Parmalee and Bogan 1998). This species requires flowing, well-oxygenated waters to thrive. Historically, this species occurred in the lower Cumberland River main stem from about the Caney Fork downstream to the vicinity of the Kentucky State line, and in the Tennessee River main stem from eastern Tennessee to western Tennessee. Records are known from two Cumberland River tributaries, Caney Fork and Red River. In addition, it is known from nearly 30 Tennessee River system tributaries, including the South Fork Powell River, Powell River, Puckell Creek, Clinch River, North Fork Holston River, Big Moccasin Creek, Middle Fork Holston River, South Fork Holston River, Holston River, French Broad River, West Prong Little Pigeon River, Tellico River, Little Tennessee River, Hiwassee River, Sequatchie River, Paint Rock River, Larkin Fork, Estill Fork, Hurricane Creek, Flint River, Limestone Creek, Elk River, Sugar Creek, Bear Creek, Duck River, North Fork Creek, Big Rock Creek, and Buffalo River. Undocumented, but now lost, populations assuredly occurred in other Cumberlandian Region tributary systems.

Populations of the slabside pearlymussel are generally considered extant (current) if live or fresh dead specimens have been collected since 1980.

Currently, it is limited to nine streams in the Tennessee River system, having been extirpated (eliminated) from the Cumberland River system and from the Tennessee River main stem.
The decline of the slabside pearlymussel in the Cumberlandian Region and other mussel species in the eastern United States is primarily the result of habitat loss and degradation. These losses have been well documented for over 130 years. Chief among the causes of decline are impoundments, stream channel alterations, water pollution, and sedimentation (Williams et al. 1992, Neves 1993, Neves et al. 1997).

4.7.11.2 Effects. The slabside pearlymussel has been extirpated throughout the entire study area. None of the potential impacts of lowering Lake Cumberland's pool could in any way affect this species.

4.7.11.3 Cumulative effects. There are no known future state, tribal, local, or private actions that are reasonably certain to occur in the action area and that would combine with navigation, water supply, recreation, flood damage reduction, hydropower, fish and wildlife, or water quality issues related to lowering the lake level of Lake Cumberland for cumulative effects on the slabside pearlymussel.

4.7.11.4 Determination. Based on the information above, a No Effect determination has been reached for the slabside pearlymussel.

4.7.12 Ring Pink (*Obovaria retusa* - Lamarck, 1819)

4.7.12.1 Species Account Summary. Detailed species descriptions can be found in Mirarchi et. al. (2004), Parmalee and Bogan (1998), and USFWS (1991e) therefore only a description summary based on these three references is provided here. The shells of mature Ring Pinks (also known as the golf stick pearly mussel) are ovate to subquadrate in outline (USFWS, 1991e). The ventral and posterior shell margins are evenly rounded and the shells are inflated, solid, and thick (Parmalee and Bogan, 1998). The umbos are sculptured with a few weak double-looped ridges and are swollen and turned anteriorly, elevated well above the hinge line (Mirarchi et. al., 2004). The shell surface is marked with noticeable low, irregular, concentric growth lines (Parmalee and Bogan, 1998). The shell exterior lacks rays and the color ranges from yellow-green to brown generally becoming darker brown to black in older individuals (USFWS, 1991e). The nacre ranges from deep purple to salmon to pink surrounded by a white shell border (USFWS, 1991e). Adults can grow to 3.75 inches (95 mm) in diameter (Mirarchi, et. al., 2004). Ring Pinks are long-term brooders and have been found gravid in August and September (Parmalee and Bogan, 1998). To date, no host fish are known for this species (Mirarchi et. al., 2004).

The Ring Pink is an Interior Basin species with a wide range (Parmalee and Bogan, 1998). Historically it was found throughout the Ohio, Tennessee, and Cumberland River systems including major tributaries in the states of Pennsylvania, West Virginia, Ohio, Indiana, Illinois, Kentucky, Tennessee, and Alabama (USFWS, 1991e). The Ring Pink was federally listed as an Endangered species in 1989 and a recover plan was written in 1991 (USFWS, 1989a, 1991e). Ring Pinks are considered big river species however they have been collected in shallow water (approximately 2 feet deep) in habitat typically consisting of sand and gravel (Parmalee and Bogan, 1998). To date, critical habitat has not been designated for this species (TVA, 2003). Since the 1970s, TVA (2003) noted that Ring Pinks were collected only from the Tennessee River below Kentucky and Pickwick dams, the Cumberland River in central Tennessee, and the Green River in Kentucky. Ring Pinks once inhabited the Cumberland River from Jackson County downstream to Stewart County and in the early 1980s, commercial mussel men collected a couple of relic individuals in Wilson, Trousdale, and Smith Counties in Tennessee (Parmalee and Bogan, 1998). Old relict individuals have recently been collected in the lower Tennessee, Holston, and middle Cumberland Rivers, however, no reproducing populations have been located in recent years (TABS, 2002c). Based on a report from the 1990s individuals may still exist in low numbers below Wilson Dam in Alabama (Mirarchi et. al., 2004). An extant population may exist in the Green River in Kentucky (KCWCS, 2005) The National Park Service (2003a) plans to propagate and restore freshwater mussels in a reach of the Green River near the Mammoth Cave Nation Park that is inhabited by seven federally endangered mussels including the Ring pink.

4.7.12.2 Effects. No individuals have been collected from the Cumberland River since the early 1990s, and those were old specimens or relics. They are likely extirpated from the area of possible effect. Water quality is a concern for this species. If Lake Cumberland does not store and release its customary volumes of water during the summer months, all aquatic species downstream from Wolf Creek Dam could incur additional stress. This would mimic to some extent what would occur in a natural system during low summer flows. Stressors would be minor and primarily be in the form of lowered DO and increased temperatures, but would also include less dilution of pollutants being discharged into the river.

4.7.12.3 Cumulative effects. The impact of Lake Cumberland on the Cumberland River System is significant. Normally 60% to 70% of the water in the Cumberland River flows from Wolf Creek Dam. In the interest of public safety and to relieve pressure on the foundation of Wolf Creek Dam, Lake Cumberland has been lowered. At the same time, the Corps is contemplating lowering Center Hill Lake for needed repairs to that dam. Flows from Wolf Creek Dam are significantly lower than what the public has become accustomed to. Anticipated cumulative effects include significantly changed and reduced water quality for all reaches below Wolf Creek Dam including lower DO, increased water temperatures, and lessened dilution of pollutants.

4.7.12.4 Determination. Based on the information above, a May Effect, but Not Likely to Adversely Affect determination has been reached for the ring pink.

4.7.13 Little-Wing Pearly Mussel (*Pegias fabula*)

4.7.13.1 Species Account Summary. The little-wing pearly mussel is small, not exceeding 1.5 inches (3.8 cm) in length and 0.5 inches (1.3 cm) in width. Like other freshwater mussels, the little-wing pearly mussel feeds by filtering food particles from the water column.

This freshwater mussel has been reported historically from 27 river reaches in Alabama, North Carolina, Kentucky, Tennessee, and Virginia. Only a few small populations are known to survive in Horse Lick Creek (Jackson and Rockcastle Counties, KY), Big South Fork Cumberland River (McCreary and Wayne Counties, KY), Little South Fork Cumberland River (McCreary and Wayne Counties, KY), Cane Creek (Van Buren County, TN), North Fork Holston River (Smyth and Washington Counties, VA), Clinch River (Tazewell County, VA), and Little Tennessee River (Swain and Macon Counties, NC) (USFWS 1989, 2003).

The little-wing pearly mussel inhabits small to medium, low turbidity, cool-water, high to moderate gradient streams in the Cumberland and Tennessee River basins (Bogan and Parmalee 1983, Ahlstedt 1986). The species is commonly found near riffles on sand and gravel substrates with scattered cobbles or in sand pockets between rocks, cobbles, and boulders (Gordon and Layzer 1989, NatureServe 2003). Individuals have been found lying on top of the substratum, buried in or on top of the substratum in the transition zone between a long pool and riffle, or buried in gravel or beneath boulders and slabrock (Blankenship 1971, Starnes and Starnes 1980, Di Stefano 1984).

The species decline has resulted primarily from habitat and water quality deterioration caused by impoundments and by pollution and siltation resulting from mining, agriculture, and construction activities. Owing to the species' limited distribution, any factor that adversely modifies habitat or water quality in the short river reaches that the species inhabits could threaten its survival (USFWS 1988).

4.7.13.2 Effects. None of the known populations of the little-wing pearly mussel exist within the possible area of effect of lowering Lake Cumberland. It is therefore unlikely that the little-wing pearly mussel could be affected in any way.

4.7.13.3 Cumulative effects. There are no known future state, tribal, local, or private actions that are reasonably certain to occur in the action area and that would combine with navigation, water supply, recreation, flood damage reduction, hydropower, fish and wildlife, or water quality issues related to lowering the lake level of Lake Cumberland for cumulative effects on the white wartyback.

4.7.13.4 Determination. Based on the information above, a No Effect determination has been reached for the little-wing pearly mussel.

4.7.14 White Wartyback (*Plethobasus cicatricosus*)

4.7.14.1 Species Account Summary. Detailed species descriptions can be found in Mirarchi et. al. (2004), Parmalee and Bogan (1998), and the Endangered Species Information System (1996b) therefore only a description summary based on these three references is provided here. The shells of white wartyback mussels range from subovate to subtriangular in outline (ESIS, 1996b). The dorsal shell margin is almost straight and the posterior and ventral shell margins are evenly rounded (Parmalee and Bogan, 1998). The posterior ridge is low, narrowly rounded to somewhat flattened, and the umbos are full and elevated well above the hinge line and turn anteriorly (Mirarchi et. al., 2004). The shells are thick, solid, and considerably inflated with uneven concentric growth lines, and a row of low irregular knobs that extend diagonally across the shell surface (Parmalee and Bogan, 1998). The shell surface is cloth-like in texture and rayless (Mirarchi et. al, 2004). Shell color ranges from yellow to greenish yellow in juveniles becoming yellowish brown, in adults (Parmalee and Bogan, 2004). The nacre is silvery white and iridescent posteriorly and adults can reach up to 100 mm (3.9 inches) in diameter (Parmalee and Bogan, 2004). White wartybacks are thought to be short-term brooders that spawn in the spring and release glochidia in the summer (ESIS, 1996b). Fish hosts are unknown; however TVA (2003) notes that the 1984 U.S. Fish and Wildlife Service (1984c) recovery plan suspects that sauger (*Stizostedion canadense*) may be a possible host fish.

The White Wartyback is an Interior Basin species (Parmalee and Bogan, 1998). Populations were once found in the shoals and riffles of the Cumberland, Ohio, Kanawha, Tennessee and Wabash Rivers (TVA, 2003) in the states of Alabama, Illinois, Indiana, Kentucky, Tennessee, and West Virginia (ESIS, 1996b). White Wartybacks have been collected in habitat consisting of a silt-free mixture of gravel and sand (Mirarchi et. al., 2004).

It was historically distributed in the Wabash, Ohio, Kanawha, Cumberland, Holston, and Tennessee Rivers of the Ohio, Cumberland, and Tennessee River systems; however, no live specimens have been recovered from these drainages since the early 1900s (NatureServe 2003). According to Ahlstedt

(1984), the white wartyback may still exist in a short reach of the Tennessee River below Pickwick Dam. No living populations have been found in numerous surveys conducted in the Tennessee River since the 1960s; however, fresh dead specimens were collected in 1979 and 1982 below Pickwick Dam near Savannah, Tennessee. If this species still exists, the viability of remaining populations is extremely threatened (NatureServe 2003).

4.7.14.2 Effects. If this species still exists at all it is in the upper end of Kentucky Lake immediately below Pickwick Lock and Dam. Although Kentucky Lake is connected to the Cumberland River via an unregulated canal, the possible effects of lowering Lake Cumberland’s pool could not reach so far upstream on Kentucky Lake. The proposed action could not, therefore, affect this species.

4.7.14.3 Cumulative effects. There are no known future state, tribal, local, or private actions that are reasonably certain to occur in the action area and that would combine with navigation, water supply, recreation, flood damage reduction, hydropower, fish and wildlife, or water quality issues related to lowering the lake level of Lake Cumberland for cumulative effects on the white wartyback.

4.7.14.4 Determination. Based on the information above, a No Effect determination has been reached for the white wartyback.

4.7.15 Orange-foot Pimpleback (*Plethobasus cooperianus*)

4.7.15.1 Species Account Summary. Detailed species descriptions can be found in Mirarchi et. al. (2004), Parmalee and Bogan (1998), and the Endangered Species Information System (ESIS, 1996c), therefore only a description summary based on these three references is provided here. The shells of orangefoot pimplebacks appear nearly circular or subtriangular in outline (Parmalee and Bogan, 1998). The anterior shell margin is rounded; and the posterior shell margin is obliquely truncate dorsally and rounded ventrally (Mirarchi, et. al., 2004). The shells are solid, heavy, moderately inflated, and marked with concentric, irregular growth lines and contains numerous raised and irregular pustules on the posterior two-thirds (Parmalee and Bogan, 1998) of the shell. The umbos are high, full, and directed forward (Parmalee and Bogan, 1998). Juvenile shells contain many dark green rays that disappear with age (Mirarchi, et. al., 2004). Shell color varies from yellow-brown to a chestnut brown in color and is darker on old individuals (ESIS, 1996c). The umbo cavity is compressed and deep (ESIS, 1996c). The nacre is white to varying shades of pink inside the pallial line (Parmalee and Bogan, 1998). Living specimens have a bright orange colored foot (Mirarchi et. al., 2004). Adults can grow up to 95 mm (3.75 inches) in diameter (ESIS, 1996c). Orangefoot pimplebacks are thought to be short-term brooders that spawn in the spring and release glochidia in the summer

(ESIS, 1996c). Females have been found gravid from early June through early August (Mirarchi, et. al., 2004). Fish hosts are unknown (Mirarchi et. al., 2004).

The Orangefoot pimpleback is an Interior Basin species (Parmalee and Bogan, 1998). Historically it was found in parts of the Ohio, Cumberland, Tennessee and Wabash Rivers in the states of Alabama, Indiana, Kentucky, Ohio, Pennsylvania, and Tennessee (ESIS, 1996c). The species was once commonly found in the shoals of medium to large rivers with sand and gravel substrate (ESIS, 1996c). The Orangefoot pimpleback was federally listed in 1976 and a recovery plan was written in 1984 (ESIS, 1996c). To date, critical habitat has not been designated for this species (TVA, 2003). Since the 1970s, it was found in the lower Ohio, middle reach of the Cumberland River, and flowing reaches of the Tennessee River (TVA, 2003). In recent years, a few individuals have been located in the tailwaters of Kentucky, Pickwick, Wilson, Guntersville, Watts Bar, and Fort Loudoun Dams with the most individuals encountered below Pickwick Dam (TVA, 2003). On the Cumberland River, populations were once commonly found from Clay to Stewart Counties, however, in 1980, only a relic population was identified in Smith County, Tennessee on the Cumberland River (Parmalee and Bogan, 1998; TABS, 2002f). Living individuals are now restricted to a few places on the Tennessee River and limited reproduction appears to be taking place in Hardin County, Tennessee (TABS, 2002f), where Mirarchi et. al.(2004) noted the presence of Orangefoot pimplebacks in the tailwaters of Pickwick Dam. In Alabama, the Orangefoot pimpleback has not been reported since 1979 but it may exist in very few numbers below Wilson or Guntersville Dams (Mirarchi et. al., 2004). In Kentucky, (KCWCS, 2005) the Orangefoot pimpleback is sporadically found in the lower Ohio and Tennessee Rivers in western Kentucky. The National Park Service (2003) plans to reintroduce the Orangefoot Pimpleback into the upper Cumberland River system in the Big South Fork National River and Recreational Area in Kentucky and Tennessee.

4.7.15.2 Effects. Individuals or small populations of the orangefoot pimpleback may still exist throughout the study area, particularly in the tailwaters below the dams. Water quality is a concern for this species. If Lake Cumberland does not store and release its customary volumes of water during the summer months, all aquatic species downstream from Wolf Creek Dam could incur additional stress. This would mimic to some extent what would occur in a natural system during low summer flows. Stressors would be minor and primarily be in the form of lowered DO and increased temperatures, but would also include less dilution of pollutants being discharged into the river. To counter these effects the Corps monitors discharged water and when necessary discharges the water through the spillway gates rather than by generating. This ensures good oxygen levels in the tailwaters and minimizes or eliminates the stressors in the tailwater populations.

4.7.15.3 Cumulative effects. The impact of Lake Cumberland on the Cumberland River System is significant. Normally 60% to 70% of the water in the Cumberland River flows from Wolf Creek Dam. In the interest of public safety and to relieve pressure on the foundation of Wolf Creek Dam, Lake Cumberland has been lowered. At the same time, the Corps is contemplating lowering Center Hill Lake for needed repairs to that dam. Flows from Wolf Creek Dam are significantly lower than what the public has become accustomed to. Anticipated cumulative effects include significantly changed and reduced water quality for all reaches below Wolf Creek Dam including lower DO, increased water temperatures, and lessened dilution of pollutants.

4.7.15.4 Determination. Based on the information above, a May Effect, but Not Likely to Adversely Affect determination has been reached for the orange-foot pimpleback.

4.7.16 Clubshell (*Pleurobema clava*)

4.7.16.1 Species Account Summary. Detailed species descriptions can be found in Parmalee and Bogan (1998), Mirarchi et. al. (2004), and the USFWS (1994) therefore only a description summary based on these three references is provided here. The shells of mature Clubshells are wedge shaped (USFWS, 1994), solid, elongated, and triangular in outline with the umbos full and elevated above the hinge line and often projecting past the anterior margin of the shell (Mirarchi et. al., 2004). Umbo sculpture consists of a few strong, irregular and often broken ridges (Parmalee and Bogan, 1998). A sulcus may be present on older specimens. Shell color ranges from straw-yellow to light brown with distinct dark green rays that may appear as thick blotches or thin lines that are usually interrupted at the growth lines (USFWS, 1994). The nacre is white tending to be iridescent posteriorly particularly in juveniles (USFWS, 1994). Adults can grow up to 65 mm (2.6 in) in diameter (Parmalee and Bogan, 1998). Clubshells are short-term brooders that spawn in the Spring and release glochidia in the late summer of the same year, usually by July or August (USFWS, 1994). Females were found to be gravid from May to July (Mirarchi et. al., 2004). Laboratory studies indicate that potential fish hosts may include Blackside darter (*Percina maculata*), Striped shiner (*Luxilus chrysocephalus*), Logperch (*Percina caprodes*), and Central stoneroller (*Campostoma anomalum*) (TVA, 2003).

The Clubshell is an Interior Basin species (Parmalee and Bogan, 1998). Historically this species was widespread and typically collected within the Ohio River drainage system in Ohio, Indiana, Illinois, and Kentucky, although some populations were present in the Tennessee and Cumberland Rivers

(USFWS, 1994). Isolated populations were collected in Michigan, Pennsylvania, and West Virginia (USFWS, 1994). Clubshells are typically found in medium to large rivers in riffle and shoal areas with a gravel and sand substrate, although a few individuals have been found in firm sand and gravel substrate at depths of 4.6 – 5.5 m (15 –18 ft) (Parmalee and Bogan, 1998). The Clubshell was federally listed as Endangered in 1993 and a recovery plan was written in 1994 (USFWS, 1994). To date, critical habitat has not been designated for this species (TVA, 2003). In 1993, the USFWS estimated that the Clubshell's range had been reduced by at least 95% (USFWS, 1994). In 1994, this species was present in small populations in 13 different river segments in Michigan, Indiana, Ohio, Kentucky, West Virginia, and Pennsylvania with the largest viable population was found in the Tippecanoe River in Indiana (USFWS, 1994). It appears to be nearly extirpated in Tennessee with the collection of an occasional relic individual that has survived since impoundment (Parmalee and Bogan, 1998), and it is believed to be extirpated in the mainstem Tennessee River (TVA 2005) except for the nonessential experimental population discussed below. It is extirpated from Alabama (USFWS, 1993, Mirarchi et. al., 2004) and considered extirpated from Illinois (USFWS, 1993). In Kentucky, Clubshells occur sporadically in the upper Green River where populations seem to be recruiting (KCWCS, 2005). According to TVA (2003) live specimens have been reported downstream of Pickwick Dam on the Tennessee River. The USFWS (2001b) plans to establish a nonessential experimental population (NEP) for 16 mussels including the Clubshell, below Wilson Dam in Colbert County, Alabama. This area is located between Tennessee River miles (TRM 259.4 - 246.0) and includes the lower 5 mile reaches of tributaries entering the Wilson Dam tailwaters (USFWS, 2001b) that under Section 10(j) of the Endangered Species Act, cannot be designated as critical habitat for a NEP (USFWS, 2001b). The NPS (2003) plans to reintroduce the Clubshell into the upper Cumberland River system in the Big South Fork National River and Recreational Area in Kentucky and Tennessee. The NPS (2003a) also plans to propagate and restore freshwater mussels in a reach of the Green River near the Mammoth Cave Nation Park that is inhabited by seven federally endangered mussels including the Clubshell.

4.7.16.2 Effects. Although it was once extant on both the Tennessee and Cumberland Rivers, this species appears to have been extirpated throughout the study area. None of the potential impacts of lowering Lake Cumberland's pool could in any way affect this species.

4.7.16.3 Cumulative effects. There are no known future state, tribal, local, or private actions that are reasonably certain to occur in the action area and that would combine with navigation, water supply, recreation, flood damage reduction, hydropower, fish and wildlife, or water quality issues related to lowering the lake level of Lake Cumberland for cumulative effects on the clubshell.

4.7.16.4 Determination. Based on the information above, a No Effect determination has been reached for the clubshell.

4.7.17 Rough Pigtoe (*Pleurobema plenum*)

4.7.17.1 Species Account Summary. Detailed species descriptions can be found in Parmalee and Bogan (1998) Mirarchi et. al. (2004) and the Endangered Species Information System (ESIS, 1996d) therefore only a description summary based on these three references is provided here. The shells of mature rough pigtoes are solid, inflated, and subtriangular in outline (Parmalee and Bogan, 1998). The umbos are full, high, turned forward, projecting well above the hinge line and are sculptured with a few irregular nodulous ridges (Parmalee and Bogan, 1998). The posterior ridge is narrowly rounded and ends bluntly; the median ridge is high, wide, and rounded and separated from the posterior ridge by a radial depression (ESIS, 1996d). A shallow sulcus is often present just anterior to the posterior ridge Mirarchi et. al., 2004). The shells are marked with irregular growth lines and are satin-like in appearance (ESIS, 1996d). Shells may be unrayed or marked with a series of fine dark green lines over the posterior half of the shell or umbo that often erodes away with age (Parmalee and Bogan, 1998). Shell color varies from yellowish brown to reddish brown and the nacre is usually white and occasionally pink (Mirarchi et. al., 2004). Adults can grow up to 80 mm (3.1 inches) in diameter (Parmalee and Bogan, 1998). Rough pigtoes are thought to be short-term brooders with females found to be gravid in May (Parmalee and Bogan, 1998). According to the Freshwater Mollusk Conservation Society's Triennial Unionid Report (1998), host fish are unknown, however, possible host fish might be Bluegill (*Lepomis marochirus*), and Rosefin shiner (*Lythrurus ardens*).

Rough pigtoes are Interior Basin species (Parmalee and Bogan, 1998). Historically it was collected within the Ohio, Tennessee, and Cumberland River drainages in Alabama, Arkansas, Illinois, Indiana, Iowa, Kansas, Kentucky, Missouri, Ohio, Pennsylvania, Tennessee, Virginia, and West Virginia (ESIS, 1996d). Rough pigtoes were historically found in medium to large rivers with a firmly packed gravel and sand substrate (Parmalee and Bogan, 1998). Specimens have been collected in muddy sand in the Green River and sand in the Clinch River in water depths of 0.8 m (2.6 ft) and 1.0 m (3.3 ft) respectively (ESIS, 1996d). Relic individuals have been collected from water depths ranging between 3.7 – 4.6 m (12 - 15 feet) deep in the Cumberland River in Smith County, Tennessee (Parmalee and Bogan, 1998). The Rough Pigtoe was federally listed in 1976, and a recovery plan was written in 1984 (ESIS, 1996d). To date, critical habitat has not been designated for this species (TVA, 2003). According to the USFWS (1984b) the Rough pigtoe has been collected from 20 sites in the Green, Barren, Clinch, Tennessee, and Cumberland River systems. On the Cumberland, relic individuals were collected in Smith and Trousdale Counties in Tennessee and on the Tennessee River, upstream Chattanooga, Tennessee (Parmalee and Bogan, 1998). TVA (2003) encountered rough pigtoes in flowing reaches downstream of Pickwick, Wilson, Guntersville, and Watts Bar dams, and in the upstream reaches of Pickwick and Wheeler Reservoirs. In Alabama, rare, extant populations exist below Wilson Dam tailwaters and possibly below Guntersville Dam tailwaters on the Tennessee River (Mirarchi, et. al., 2004). In Kentucky, Rough pigtoes sporadically occur in the Green and Barren Rivers (KCWCS, 2005). In Tennessee, only a few relict specimens exist in remaining mussel beds of the lower Clinch and Holston rivers; and throughout the Tennessee and upper Cumberland Rivers (TABS, 2005f). The National Park Service (NPS) (2003a) plans to propagate and restore freshwater mussels in a reach of the Green River near the Mammoth Cave Nation Park that is inhabited by seven federally endangered mussels including the Rough Pigtoe. The species currently is known to survive downstream of three Tennessee River mainstem dams (Pickwick, Wilson, and Guntersville) and in the Clinch River (between river miles 323 and 154) (NatureServe 2003). In 1984, the rough pigtoe was also reported in the Green River in Kentucky (below locks 4 and 5) and in the Barren River (below lock and dam 1) (USFWS 1984).

4.7.17.2 Effects. Only a few relict specimens may exist throughout the Tennessee and upper Cumberland Rivers. Only historic (pre 1970) records exist on the Cumberland River. Individuals or small populations may still exist in the Tennessee River, Kentucky Lake. Although Kentucky Lake is connected to the Cumberland River via an unregulated canal, the possible effects of lowering Center Hill's pool could not reach so far upstream on Kentucky Lake. The proposed action could not, therefore, affect this species.

4.7.17.3 Cumulative effects. The impact of Lake Cumberland on the Cumberland River System is significant. Normally 60% to 70% of the water in the Cumberland River flows from Wolf Creek Dam. In the interest of public safety and to relieve pressure on the foundation of Wolf Creek Dam, Lake Cumberland has been lowered. At the same time, the Corps is contemplating lowering Center Hill Lake for needed repairs to that dam. Flows from Wolf Creek Dam are significantly lower than what the public has become accustomed to. Anticipated cumulative effects include significantly changed and reduced water quality for all reaches below Wolf Creek Dam including lower DO, increased water temperatures, and lessened dilution of pollutants.

4.7.17.4 Determination. Based on the information above, a No Effect determination has been reached for the rough pigtoe.

4.7.18 Fluted Kidneyshell (*Ptychobranchus subtentum*)

4.7.18.1 Species Account Summary. The fluted kidneyshell is a relatively large mussel that reaches about 13 centimeters (5 inches) in length. The shape of the shell is roughly oval elongate, and the solid, relatively heavy valves are moderately inflated. A series of flutings (corrugations) characterizes the posterior slope of each valve. Shell texture is smooth and somewhat shiny in young specimens, becoming more dull with age. Shell color is greenish yellow, becoming brownish with age, with several broken, wide green rays. Internally, the pseudocardinal teeth are stumpy and triangular in shape. The lateral teeth are heavy. The color of the nacre (mother-of-pearl) is bluish white to dull white with a wash of salmon in the older part of the shell (beak cavity).

Adult freshwater mussels are filter-feeders, siphoning phytoplankton, diatoms, and other microorganisms from the water column. For their first several months juvenile mussels employ foot (pedal) feeding, and are thus suspension feeders that feed on algae and detritus. Mussels tend to grow relatively rapidly for the first few years, then slow appreciably at sexual maturity (when energy is being diverted from growth to reproductive activities). As a group, mussels are extremely long-lived, living from a few decades to a maximum of approximately 200 years. Large, heavy-shelled riverine species tend to have longer life spans. No age specific information is available for the fluted kidneyshell. However, considering that it is a fairly large, heavy-shelled riverine species, it would seem probable that it is relatively long-lived.

The fluted kidneyshell is primarily a small river to large creek species, inhabiting sand and gravel substrates in relatively shallow riffles and shoals with moderate to swift current (Parmalee and Bogan 1998). This species requires flowing, well-oxygenated waters to thrive.

Most studies of the distribution and population status on the fluted kidneyshell presented in this section were conducted in the first quarter of this century and since the early 1960s. The fluted kidneyshell is a Cumberlandian Region mussel, meaning it is restricted to the Cumberland (in Kentucky and Tennessee) and Tennessee (in Alabama, Tennessee, and Virginia) River systems.

Populations of the fluted kidneyshell are generally considered extant (current) if live or fresh dead specimens have been collected since 1980. Currently, it is limited to eight streams in the Cumberland River system and seven streams in the Tennessee River system. Cumberland River system tributaries with extant populations include the Middle Fork Rockcastle River, Horse Lick Creek, Buck Creek, Rock Creek, Kennedy Creek, Little South Fork, Wolf River, and West Fork Obey River. Presently, this species is also known in the Powell River, Indian Creek, Little River, Clinch River, Copper Creek, North Fork Holston River, and Middle Fork Holston River in the Tennessee River system. Extirpated (eliminated) from both the Cumberland and Tennessee River main stems, the fluted kidneyshell has also been eliminated from about 62% of the total number of streams from which it was historically known. The certainty that the fluted kidneyshell occurred in other streams within its historical range increases the percentage of lost habitat and populations, thus making its present status that much more imperiled.

The decline of the fluted kidneyshell in the Cumberlandian Region and other mussel species in the eastern United States is primarily the result of habitat loss and degradation. These losses have been well documented for over 130 years. Chief among the causes of decline are impoundments, stream channel alterations, water pollution, and sedimentation (Williams et al. 1992, Neves 1993, Neves et al. 1997).

Impoundments result in the dramatic modification of riffle and shoal habitats and the resulting loss of mussel resources, especially in larger rivers. Impoundment impacts are most profound in riffle and shoal areas, which harbor the largest assemblages of mussel species, including the fluted kidneyshell. Dams interrupt most of a river's ecological processes by modifying flood pulses; controlling impounded water elevations; altering water flow, sediments, nutrients, energy inputs and outputs; increasing depth; decreasing habitat heterogeneity; and decreasing bottom stability due to subsequent sedimentation. The reproductive process of riverine mussels is generally disrupted by impoundments, making the fluted kidneyshell unable to successfully reproduce and recruit under reservoir conditions.

In addition, dams can also seriously alter downstream water quality and riverine habitat, and negatively impact tailwater mussel populations. These changes include thermal alterations immediately below dams; changes in channel characteristics, habitat availability, and flow regime; daily discharge fluctuations; increased silt loads; and altered host fish communities. Coldwater releases from large non-navigational dams and scouring of the river bed from highly fluctuating, turbulent tailwater flows have also been implicated in the demise of mussel faunas. Population losses due to impoundments have probably contributed more to the decline of the fluted kidneyshell and other Cumberlandian Region mussels than has any other single factor.

4.7.18.2 Effects. Based on the above, the fluted kidneyshell historically was widespread in the upper Tennessee and Cumberland River systems; but has been extirpated from all of the mainstem areas of both the Cumberland and Tennessee Rivers. This species has apparently been extirpated throughout the study area. None of the potential impacts of lowering Lake Cumberland's pool could in any way affect this species.

4.7.18.3 Cumulative effects. There are no known future state, tribal, local, or private actions that are reasonably certain to occur in the action area and that would combine with navigation, water supply, recreation, flood damage reduction, hydropower, fish and wildlife, or water quality issues related to lowering the lake level of Lake Cumberland for cumulative effects on the Appalachian monkeyface.

4.7.18.4 Determination. Based on the information above, a No Effect determination has been reached for the fluted kidneyshell.

4.7.19 Appalachian Monkeyface (*Quadrula sparsa*)

4.7.19.1 Species Account Summary. The Appalachian monkeyface is a medium-sized freshwater mussel (reaching up to 70 mm in length) with a yellow-green or brown shell and small greenish triangles. Like other freshwater mussels, the Appalachian monkeyface feeds by filtering food particles from the water column. The specific food habits of the species are unknown, but other juvenile and adult freshwater mussels have been documented to feed on detritus, diatoms, phytoplankton, and zooplankton (Churchill and Lewis 1924). The diet of Appalachian monkeyface glochidia, like other freshwater mussels, comprises water (until encysted on a fish host) and fish body fluids (once encysted).

The reproductive cycle of the Appalachian monkeyface is similar to that of other native freshwater mussels. Males release sperm into the water column; the sperm are then taken in by the females through their siphons during feeding and respiration. The females retain the fertilized eggs in their gills until the larvae (glochidia) fully develop. The mussel glochidia are released into the water, and within a few days they must attach to the appropriate species of fish, which they parasitize for a short time while they develop into juvenile mussels. They then detach from their fish host and sink to the stream bottom or other substrate where they continue to develop, provided they land in a suitable substratum with the correct water conditions. Adult mussels of this species are sexually dimorphic. Specific glochidial host species for the Appalachian monkeyface are not known.

The Appalachian monkeyface historically was widespread in the upper Tennessee and Cumberland River systems; however, it is currently found only in the free-flowing reaches of the of the Powell and Clinch Rivers above Norris Reservoir in Tennessee and in one section of the Powell and Clinch Rivers in Virginia (USFWS 1984, Neves 1991, NatureServe 2003). The Clinch River population in Virginia may not be viable due to isolated distribution and low numbers (Neves 1991).

The Appalachian monkeyface typically occurs in shallow shoal and riffle areas in free-flowing streams of moderate gradient. Substrate preferences include firm rubble, gravel and sand and the species most often remains buried with only siphons visible (USFWS 1984, ESIS 1996, VFWIS 2003).

Many of the historic populations of the Appalachian monkeyface were apparently lost when the river sections they inhabited were impounded. Over 50 impoundments on the Tennessee and Cumberland Rivers have eliminated the majority of riverine habitat for the species in its historic range (ESIS 1996, USFWS 1984). The Powell River and upper tributaries of the Clinch River, in particular, are also subject to sediment and particulate matter loading from coal mining activities (Stansbery 1973). Other threats that are attributed to population declines are similar to those described in the general mussel description.

4.7.19.2 Effects. Based on the above, the Appalachian monkeyface historically was widespread in the upper Tennessee and Cumberland River systems; but is currently found only in the free-flowing reaches of the of the Powell and Clinch Rivers above Norris Reservoir in Tennessee and in one section of the Powell and Clinch Rivers in Virginia. This species has apparently been extirpated throughout the study area. None of the potential impacts of lowering Lake Cumberland's pool could in any way affect this species.

4.7.19.3 Cumulative effects. There are no known future state, tribal, local, or private actions that are reasonably certain to occur in the action area and that would combine with navigation, water supply, recreation, flood damage reduction, hydropower, fish and wildlife, or water quality issues related to lowering the lake level of Lake Cumberland for cumulative effects on the Appalachian monkeyface.

4.7.19.4 Determination. Based on the information above, a No Effect determination has been reached for the Appalachian monkeyface.

4.7.20 Cumberland Bean (*Villosa trabalis*)

4.7.20.1 Species Account Summary. The Cumberland bean pearlymussel is a small to medium sized freshwater mussel with relatively thick, elongated, oval shells. The shells of the females are somewhat more rounded and slightly larger (maximum about 55 millimeters or 2.2 inches long) (Parmalee and Bogan 1998; USFWS 1984). Like other freshwater mussels, the Cumberland bean pearlymussel feeds by filtering food particles from the water column. The specific food habits of the species are unknown, but other juvenile and adult freshwater mussels have been documented to feed on detritus, diatoms, phytoplankton, and zooplankton (Churchill and Lewis 1924). The diet of Cumberland bean pearlymussel glochidia, like other freshwater mussels, comprises water (until encysted on a fish host) and fish body fluids (once encysted).

The reproductive cycle of the Cumberland bean pearlymussel is similar to that of other native freshwater mussels. Males release sperm into the water column; the sperm are then taken in by the females through their siphons during feeding and respiration. The females retain the fertilized eggs in their gills until the larvae (glochidia) fully develop. The mussel glochidia are released into the water, and within a few days they must attach to the appropriate species of fish, which they parasitize for a short time while they develop into juvenile mussels. They then detach from their fish host and sink to the stream bottom or other substrate where they continue to develop, provided they land in a suitable substratum with the correct water conditions. Spawning likely occur in late summer through early fall; the glochidia are likely released in late spring and early summer (Schultz 1996). Two fish have been identified as glochidial hosts, the fantail darter (*Etheostoma flabellare*) and striped darter (*Etheostoma virgatum*) (Layzer and Madison 1995).

The Cumberland bean pearlymussel was historically known from ten river systems in the Cumberland and Tennessee River basins in Alabama, Georgia, Kentucky, Tennessee, and Virginia (USFWS 1984). The Cumberland bean currently survives only in the Hiwassee River in Tennessee and in Buck Creek, the Little South Fork of the Cumberland River, and the Rockcastle River system in Kentucky (USFWS 2001). A relatively strong population still exists in a short reach of the Hiwassee River downstream of the North Carolina/Tennessee State line in Polk County, Tennessee (Parmalee and Bogan 1998). Although no specimens have been collected in North Carolina, the habitat appears suitable, and it is likely that the species occurs in small numbers in the North Carolina portion of the Hiwassee River below Appalachia Dam, Cherokee County (J. Fridell, USFWS, personal communication 2000).

The Cumberland bean pearlymussel inhabits small rivers and streams in fast riffles with gravel or sand and gravel substrate. Individuals have been found in riffle and run habitat areas with shallow water depths (less than one meter) and clean, stable substrate. Individuals can often be found in transitional zones between sand and gravel substrates (USFWS 1984; Clark 1981; NatureServe 2003).

The Cumberland bean pearlymussel has been directly impacted by impoundments, siltation, channelization, and water pollution. Reservoir construction is the most obvious cause of the loss of mussel diversity in the basin's larger rivers. Most of the main stem of both the Tennessee and Cumberland River and many of their tributaries are impounded. For example, over 2,300 river miles or about 20 percent of the Tennessee River and its tributaries with drainage areas of 25 square miles or greater are impounded

(Tennessee Valley Authority 1971). In addition to the loss of riverine habitat within impoundments, most impoundments also seriously alter downstream aquatic habitat; and mussel populations upstream of reservoirs may be adversely affected by changes in the fish fauna essential to a mussel's reproductive cycle (USFWS 2003). Coal mining related siltation and associated toxic runoff have adversely impacted many stream reaches. Numerous streams have experienced mussel and fish kills from toxic chemical spills, and poor land use practices have fouled many waters with silt. Runoff from urban areas has degraded water and substrate quality. Because of the extent of habitat destruction, the overall aquatic faunal diversity in many of the basins' rivers has declined significantly (USFWS 1984).

The low number of individuals and the restricted range of each of the surviving populations make them extremely vulnerable to extirpation from a single catastrophic event or activity, such as a toxic chemical spill or major channel alteration. Pollutant threats to freshwater mussels are well documented in the general mussel description.

4.7.20.2 Effects. The Cumberland bean currently survives only in the Hiwassee River in Tennessee and in Buck Creek above the possible impact of altering Lake Cumberland's pool, the Little South Fork of the Cumberland River, and the Rockcastle River system in Kentucky (USFWS 2001). This species has apparently been extirpated throughout the study area. None of the potential impacts of lowering Lake Cumberland's pool could in any way affect this species.

4.7.20.3 Cumulative effects. There are no known future state, tribal, local, or private actions that are reasonably certain to occur in the action area and that would combine with navigation, water supply, recreation, flood damage reduction, hydropower, fish and wildlife, or water quality issues related to lowering the lake level of Lake Cumberland for cumulative effects on the Cumberland bean pearlymussel.

4.7.20.4 Determination. Based on the information above, a No Effect determination has been reached for the Cumberland bean pearlymussel.

5.0 Potential Conservation Measures

These following discretionary measures have been developed for consideration as actions that could be undertaken by the Nashville District as reasonable and prudent measures.

5.1 Measure No. 1. Installation of an Orifice Gate Over a Sluice Gate. In 2004 the Corps Conducted a study titled *Center Hill Tailwater Modeling for Minimum Flow Evaluation* that found the optimum minimum flow below Center

Hill is about 200 cfs. Even a single sluice gate far exceeds this volume (about 1,500 cfs) and it often exceeds the inflow into the lake. To provide minimum flow the Corps has tried pulsing the flows through a single sluice gate with unsatisfactory results. The flow is too much to be sustained and the slope of the river bed rapidly drains the discharged water so that frequent pulsing is required. One solution may be installing an orifice gate over a sluice gate. The orifice gate would limit the discharge to about 280 cfs, providing a constant minimum flow with high levels of DO. Two orifice gates are currently being installed on Wolf Creek Dam. This would benefit the tailwater of Wolf Creek Dam.

5.2 Blending Turbine and Sluice Gate Discharges. The average discharge of water from a turbine at Wolf Creek Dam is between 3,500 and 4,000 cfs depending on the lake level. During the warmer months of the year, i.e., roughly May through October, the water stratifies and virtually all DO in the deeper portions of the lake is consumed by ongoing chemical and biological processes. Consequently, water discharged through the turbines is very low in DO and the tailwater ecology suffers. In recent years the Corps has been experimenting with releases through the sluice gates to compensate for this problem. Water discharged through the sluice gates can have as much as 10 mg/l of DO. Each of the six sluice gates can discharge about 1,500 cfs. Thus, when generation is required during the warmer months a sluice gate can be opened and as the waters from the turbines and the sluices blend adequate DO is achieved. This would benefit the tailwater of Wolf Creek Dam.

5.3 Supplemental Flows from Other Tributary Lakes. It may be possible to store some excess water in Dale Hollow and/or J. Percy Priest Lakes early in the year and slowly release this water over the summer to mitigate for the reduced flows from Wolf Creek Dam. This course of action would be dependent on several factors including the amount of rainfall and several operational factors. This was done to a limited extent in 2007 when Dale Hollow was filled to about to about elevation 653, or approximately two feet above the top of the power pool. This action would have to be planned and approved in advance to make any significant difference.

5.4 Spill vs. Generation. As noted above, the preferred method for regulating lake levels is by hydropower generation. However, during the summer months when water quality in the mainstem lakes typically decreases, the Corps has occasionally resorted to spilling water through the tainter gates rather than by generating because this increases the DO in the tailwater where most of the species of concern are likely to be found. The disadvantage of this, of course, is the power lost by foregoing hydropower generation.

5.5 Trout Hatchery Modifications. The Corps has been and will continue to work closely with the FWS to minimize impacts to the hatchery. Two auxiliary pumps were installed in the tailwater to supply additional water to the hatchery. An alarm system has been installed to alert both the FWS and the Corps in the event of a pump failure and the dam's control room is staffed at all times. Should there be a pump failure the second pump would be started manually. The Corps is also exploring an automatic switching system that would change pumps in the event of a pump failure. The Corps has also been consulting with the FWS regarding the multi-level intakes structure. The structure has several ports that allow FWS to select and blend water from different levels of the lake based on temperature and oxygen demands. Last year the structure was lowered at the request of FWS. In January 2008, divers are scheduled to repair a leak in the structure and to repair a malfunctioning valve. These actions will enable FWS to better regulate the water being drawn from the lake.

5.6 Water Quality Monitoring. The Corps currently has near real time water monitoring and data. In the past the Corps conducted four trips per year to collect water quality data. Two of these trips conducted profiles and full chemical analyses and the other two checked profiles only. The Corps also conducted biweekly grab sampling of in situ parameters during the warm season, i.e., May through November and monthly grab samples from December through April. Since declaring the emergency the Corps has increased its monitoring and now conducts three full samples and two for profiles only. The Corps also now conducts biweekly collections of profiles in the forebay and upstream stations to define water quality conditions from April through December and Monthly collections from January through March. Data is collected in the tailwater and other downstream locations as needed, specifically at Cumberland River Miles 459, 456, and 437 and have installed temperature probes. Monitoring data is immediately fed back into decision making processes and is sent to affected parties (mostly agencies).

6.0 Species/Impact Summary/Conclusions and Determinations

The effects of lowering Lake Cumberland were assessed and found to be limited to changes to water quality. Determination of these potential effects on the species list is summarized in Table 3, below. The analyses of the effects under Corps Nashville District purview in Chapter 4.0, above support an unqualified "no effect" determination for all mammal, bird, insect, and plant species. Several species of fish and bivalves were also determined to be in the No Effect category. By itself, the action of lowering Lake Cumberland could affect some of the remaining species of concern and a determination of May Affect was reached for several species. These species are also identified in Table 3 below.

The Endangered Species Act not only directs that Federal agencies insure that their actions are not likely to jeopardize the continued existence of a listed species or adversely affect its critical habitat, but also directs that they utilize their authorities to further the conservation of listed species. In the spirit of both directives of the Act, the Nashville District proposes a series of conservation measures in Chapter 5, above. Their implementation will not only help to avoid adversely impacting listed species by lowering Lake Cumberland, but proactively further the conservation of these species.

Summary of Effect Determinations

Scientific Name	Common Name	Status	Class	Impact
Alasmidonta atropurpurea	Cumberland Elktoe	LE	Bivalvia	No Effect
Apios priceana	Price's Potato-bean	LT	Magnoliopsida	No Effect
Arabis perstellata	Braun's Rockcress	LE	Magnoliopsida	No Effect
Astragalus bibullatus	Pyne's Ground-plum	LE	Magnoliopsida	No Effect
Charadrius melodus	Piping Plover	LE	Aves	No Effect
Conradina verticillata	Cumberland Rosemary	LT	Magnoliopsida	No Effect
Cumberlandia monodonta	Spectaclecase	C	Bivalvia	No Effect
Cyprogenia stegaria	Fanshell	LE	Bivalvia	May Affect, Not Likely to Adversely Affect.
Dalea foliosa	Leafy Prairie-clover	LE	Magnoliopsida	No Effect
Dromus dromas	Dromedary Pearlymussel	LE	Bivalvia	May Affect, Not Likely to Adversely Affect.
Echinacea tennesseensis	Tennessee Coneflower	LE	Magnoliopsida	No Effect
Epioblasma brevidens	Cumberlandian Combshell	LE	Bivalvia	May Affect, Not Likely to Adversely Affect.
Epioblasma capsaeformis	Oyster Mussel	LE	Bivalvia	No Effect
Epioblasma florentina walkeri	Tan Riffleshell	LE	Bivalvia	No Effect
Epioblasma obliquata obliquata	Catspaw or Purple Cat's Paw	LE	Bivalvia	May Affect, Not Likely to Adversely Affect.
Etheostoma boschungi	Slackwater Darter	LT	Actinopterygii	No Effect
Hemistena lata	Cracking Pearlymussel	LE	Bivalvia	No Effect
Lampsilis abrupta	Pink Mucket	LE	Bivalvia	May Affect, Not Likely to Adversely Affect.
Lesquerella globosa	Short's Bladderpod	C	Magnoliopsida	No Effect
Lesquerella perforata	Spring Creek Bladderpod	LE	Magnoliopsida	No Effect
Lexingtonia dolabelloides	Slabside Pearlymussel	C	Bivalvia	No Effect
Myotis grisescens	Gray Bat	LE	Mammalia	No Effect
Myotis sodalis	Indiana Bat	LE	Mammalia	No Effect
Notropis albizonatus	Palezone Shiner	LE	Actinopterygii	No Effect
Noturus stanauli	Pygmy Madtom	LE	Actinopterygii	No Effect
Obovaria retusa	Ring Pink	LE	Bivalvia	May Affect, Not Likely to Adversely Affect.
Orconectes shoupi	Nashville Crayfish	LE	Malacostraca	No Effect
Pegias fabula	Little-wing Pearlymussel	LE	Bivalvia	No Effect
Phoxinus cumberlandensis	Blackside Dace	LE	Actinopterygii	No Effect
Plethobasus cicatricosus	White Wartyback	LE	Bivalvia	No Effect
Plethobasus cooperianus	Orange-foot Pimpleback	LE	Bivalvia	May Affect, Not Likely to Adversely Affect.
Pleurobema clava	Clubshell	LE	Bivalvia	No Effect
Pleurobema plenum	Rough Pigtoe	LE	Bivalvia	No Effect
Pseudanophthalmus colemanensis	A Cave Obligate Beetle	C	Insecta	No Effect
Pseudanophthalmus fowlerae	Fowler’s Cave Beetle	C	Insecta	No Effect
Pseudanophthalmus inquisitor	Searcher Cave Beetle	C	Insecta	No Effect
Pseudanophthalmus insularis	Baker Station Cave Beetle	C	Insecta	No Effect
Ptychobranchus subtentum	Fluted Kidneyshell	C	Bivalvia	No Effect
Quadrula sparsa	Appalachian Monkeyface	LE	Bivalvia	No Effect
Sterna antillarum athalassos	Interior Least Tern	LE	Aves	No Effect
Villosa trabalis	Cumberland Bean	LE	Bivalvia	No Effect

Table 3

Appendix B

US Fish and Wildlife Coordination Act Report

Appendix C

Responses to Scoping Letter and Notice of Intent

United States Department of the Interior

FISH AND WILDLIFE SERVICE
3761 Georgetown Road
Frankfort, Kentucky 40601

February 12, 2007

Mr. Chip Hall
Project Planning Branch
U.S. Army Corps of Engineers
P.O. Box 1070 (PM-P)
Nashville, Tennessee 37202-1070

Subject: FWS #2007-B-0579; Notice of Intent to Operate Wolf Creek Dam, Lake Cumberland, at Below Normal Pool Levels Due to Emergency Conditions (ER 07/0101)

Dear Mr. Hall:

This letter is in response to the U.S. Army Corps of Engineers' (Corps) February 2, 2007 Federal Register Notice (72 Federal Register 5020-5021) requesting comments on the proposed rehabilitation of Wolf Creek Dam. The Corps intends to operate Wolf Creek Dam at levels that are below normal pool for an extended period of time so that emergency repairs to the dam can be completed. The emergency repairs are necessary to avoid a failure of the earthen dam, which would reduce the risk to the public's safety and welfare. Due to the emergency nature of the action, the Corps has already begun to reduce the water level. Ordinarily, the Corps would conduct its NEPA analysis and other regulatory requirements, including Endangered Species Act section 7 consultation, prior to initiation of the action. The Fish and Wildlife Service (Service) has reviewed the information submitted and offers the following comments under the provisions of the Fish and Wildlife Coordination Act and the Endangered Species Act.

Wolf Creek Dam is located in Russell County, Kentucky, and impounds the Cumberland River to form Lake Cumberland. Lake Cumberland and its embayments lie within Russell, Clinton, Wayne, McCreary, Laurel, Whitley, and Pulaski counties. A total of 25 federally listed and federal candidate species are known from these counties or have the potential to occur in these counties. These species are shown in Table 1 below.

The Corps should determine if the proposed action has the potential to cause adverse effects on these species. For example, the following streams containing the threatened blackside dace (*Phoxinus cumberlandensis*) are direct tributaries to the impounded, upper reaches of Lake Cumberland: (a) Big Lick Branch and one of its tributaries in Pulaski County; (b) Ned Branch (a Rockcastle River tributary) in Laurel County; and (c) Beaver Creek, Fish Trap Branch, and Mill Creek in McCreary County. Lowered lake levels may cause destabilization of stream channels (i.e., head-cuts that could migrate upstream) that could potentially impact blackside dace habitat in these streams, which would be considered an indirect, adverse effect to this species.

Additionally, Critical Habitat has been designated in several of these counties for three federally listed mussel species. These critical habitat areas are located in watersheds that are tributaries to the Cumberland River above Wolf Creek Dam. These mussels and their designated Critical Habitat are listed below:

- Cumberland elktoe – Big South Fork, Marsh Creek, and Rock Creek – McCreary County; Sinking Creek, Laurel County; Laurel Fork, Whitley County (69 FR 53136-53180, August 2004)

- Cumberlandian combshell – Big South Fork, McCreary County; Buck Creek, Pulaski County (69 FR 53136-53180, August 2004)

- Oyster mussel – Big South Fork, McCreary County; Buck Creek, Pulaski County (60 FR 53136-53180, August 2004)

The Corps should determine if the proposed project will result in the adverse modification of these critical habitat areas.

We also recommend that the Corps carefully monitor habitat conditions in the upper portions of Lake Cumberland that will be de-watered. In particular, we are interested in determining if suitable aquatic and/or terrestrial (e.g., caves) habitat conditions for federally listed species will be temporarily restored to these areas. If listed species colonize such areas, additional adverse effects may occur when the Corps returns Lake Cumberland to its normal pool. The Corps should pay particular attention to restored stream reaches and to any caves openings that may be uncovered. Surveys of these habitats will likely be necessary prior to re-filling Lake Cumberland to determine if federally listed fish, mussels, and bats have colonized the restored habitats.

Based on these issues and the high number of potentially affected listed species, we believe that the Corps should initiate informal section 7 consultation on the proposed action and should be prepared to consult formally if adverse effects are likely to result from the proposed action.

If you have any questions on these comments, please contact me at 502/695-0468 x108.

Sincerely,

Virgil Lee Andrews, Jr.

Virgil Lee Andrews, Jr.
Field Supervisor

Table 1. Federally listed and federal candidate species with the potential to occur or with known occurrences in the Cumberland River watershed upstream of Wolf Creek Dam, Russell County, Kentucky

Common Name	Scientific Name	Federal Status	Counties						
			Clinton	Laurel	McCreary	Pulaski	Russell	Wayne	Whitley
Mammals									
Indiana bat	*Myotis sodalis*	endangered	x	x	x	x	x	x	x
gray bat	*Myotis grisescens*	endangered	x	x		x		x	x
Birds									
bald eagle	*Haliaeetus leucocephalus*	threatened		x					x
Fishes									
blackside dace	*Phoxinus cumberlandensis*	threatened		x	x	x			x
palezone shiner	*Notropis albizonatus*	endangered			x			x	
duskytail darter	*Etheostoma percnurum*	endangered			x				
Cumberland darter	*Etheostoma susanae*	candidate			x				x
Mussels									
Cumberland bean	*Villosa trabilis*	endangered	x	x	x	x	x	x	x
Cumberlandian combshell	*Epioblasma brevidens*	endangered	x	x	x		x	x	x
Cumberland elktoe	*Alasmidonta atropurpurea*	endangered		x	x	x		x	x
fluted kidneyshell	*Ptychobranchus subtentum*	candidate	x	x	x	x	x	x	x
littlewing pearlymussel	*Pegias fabula*	endangered		x	x	x		x	x
oyster mussel	*Epioblasma capsaeformis*	endangered	x	x	x	x	x	x	x
pink mucket	*Lampsilis abrupta*	endangered			x		x	x	
spectaclecase	*Cumberlandia monodonta*	candidate			x			x	
fanshell	*Cyprogenia stegaria*	endangered			x	x	x	x	
tan riffleshell	*Epioblasma florentina walkeri*	endangered			x			x	
purple catspaw	*Epioblasma o. obliquita*	endangered				x			
ring pink	*Obovaria retusa*	endangered				x	x	x	
rough pigtoe	*Pleurobema plenum*	endangered	x			x	x	x	
orangefoot pimpleback	*Plethobasus cooperianus*	endangered	x				x	x	
Plants									
Virginia spiraea	*Spiraea virginiana*	threatened		x	x	x			x
Cumberland sandwort	*Arenaria cumberlandensis*	endangered			x				
Cumberland rosemary	*Conradina verticillata*	threatened			x				
White fringeless orchid	*Platanthera integrilabia*	candidate		x	x	x			x

From:	Vermell Davis
To:	Lake.Modification@lrn02.usace.army.mil.;
cc:	John Craynon; Vijai_Rai@ios.doi.gov;
Subject:	FW: ENVIRONMENTAL REVIEW (ER) NEW POSTING NOTIFICATION: ER 07/101
Date:	Monday, February 12, 2007 10:10:24 AM

Good Morning Chip,

These are OSM's comments on the subject environmental review. If you have any questions, please contact Dave Hartos at 412-937-2909.

Thanks
Vermell Davis
Regulatory Analyst
202-208-2802

From: Dave Hartos
Sent: Monday, February 12, 2007 10:31 AM
To: Vermell Davis
Cc: Vann Weaver; Mike Robinson; Bill Kovacic; Tim Dieringer; Lois Uranowski; John Craynon
Subject: RE: ENVIRONMENTAL REVIEW (ER) NEW POSTING NOTIFICATION: ER 07/101

Good morning Vermell,

After receiving information from our Lexington and Knoxville field offices, we have determined that the location of Wolf Creek Dam (Lake Cumberland), Kentucky is outside of the coal fields in eastern Kentucky, and no active or abandoned coal mine projects exist in the area. We conclude that our region does not have jurisdiction or special expertise to assess the impacts of operating the Wolf Creek Dam, Lake Cumberland, at below normal pool levels. We do not recommend that OSM be a "cooperating agency" on the pending EIS for this project.

Please call me if need additional information or have questions.

David Hartos, AR NEPA Coordinator
3 Parkway Center
Pittsburgh, PA 15220
Phone: (412) 937-2909

From: Vermell Davis
Sent: Thursday, February 08, 2007 1:13 PM
To: Dave Hartos
Subject: FW: ENVIRONMENTAL REVIEW (ER) NEW POSTING NOTIFICATION: ER 07/101

Hi Dave,

We have received the attached for review. Please provide any comments, if any, to me by COB February28th to be forwarded directly to COE.

Thanks
Vermell

From: oepchq@ios.doi.gov [mailto:oepchq@ios.doi.gov]
Sent: Tuesday, February 06, 2007 10:15 AM
To: Loretta_Sutton@ios.doi.gov; Vijai_Rai@ios.doi.gov; John Craynon; Stephanie_Nash@fws.gov; lwoosley@usgs.gov; BJJohnso@usgs.gov; Jacob_Hoogland@nps.gov; Dale_Morlock@nps.gov; Vermell Davis; Richard_Wheeler@ios.doi.gov; LaRoy_Williams@ios.doi.gov; atlantasecy@msn.com; Gregory_Hogue@ios.doi.gov; Joyce_Stanley@ios.doi.gov; oepcatl@msn.com
Subject: ENVIRONMENTAL REVIEW (ER) NEW POSTING NOTIFICATION: ER 07/101

This e-mail alerts you to an ER request from the Office of Environmental Policy and Compliance (OEPC). To access electronic ERs visit the OEPC Natural Resources Management Team website at: http://www.doi.gov/oepc/nrm.html <http://www.doi.gov/oepc/nrm.html%20> - Under Quick Links select: Environmental Review Distributions (Bureau ER Notifications). For assistance, please contact the Natural Resources Management Team, at 202-208-5464.

From:
To: Modification, Lake LRN;
Subject: tailwater concerns
Date: Monday, February 19, 2007 8:21:15 PM

Mr. Hall

I have a variety of concerns regarding the structural integrity of the Wolf Creek Dam and its potential impact on human safety, property concerns, and the tailwater fishery.

Of far greatest concern is the potential threat to human safety. Unfortunately, I have nearly completed construction of my lifetime dream fishing cabin on some bottom land approximately 0.5 mi upstream from Winfrey's Ferry. I now have some concerns about myself or my children spending any time there. Is this an unreasonable concern? Would you feel comfortable at such a location? What recommendations regarding safety can you make? Can you put me in contact with my local emergency management agency, Russell County, Kentucky?

A secondary concern relates to property values. Clearly, the announcement has had a dramatically negative impact on property values. Is there a mechanism proposed or in place to allow property to be reassessed so that property taxes will reflect current market value rather than purchase value? Are there any other tax/financial considerations for property owners in the former floodplain? My homeowners insurance agent claims that unless an area is officially designated as a flood area, they cannot write flood insurance policies. Is this true? Are some of the tailwater lands going to be given such a designation? Will the inundation maps serve this purpose?

I understand that an environmental impact statement will be produced, likely by May, and many of my questions regarding the fishery will likely be addressed in that document. That said, I would like to propose looking at several options for fishery preservation. First, allowing water to settle in the lake (rather than simply venting warm water runoff) should allow a thermocline to be established. This approach may necessitate have some reserve capacity in the reservoir as a buffer for heavy rains. Turbulent mixing of the cold groundwater with warm surface runoff, then directly venting into the tailwater will be toxic to the coldwater fishery. Second, active aeration in addition to passive sluice gate aeration should be considered. This may require installation of aerators along the course of the river within the at risk segment. Finally, there are warm-water tolerant subspecies of trout that could be stocked. The National Fish Hatchery should assess the viability of stocking these trout, particularly if there are significant water temperature elevations expected over a prolonged period of time, eg years.

Please respond to my safety and property concerns at your earliest convenience.

JK

From:	
To:	Modification, Lake LRN;
CC:	
Subject:	Wolf Creek Dam
Date:	Tuesday, March 27, 2007 11:18:42 AM
Attachments:	

Increased electric bills and minor inconvenience to fishermen/boaters can hardly be compared to the loss of life and property that would result from failure of Wolf Creek Dam.

I am far more concerned for human life than the impact on "fish and aquatic life".

Mount Juliet TN

Date: 28 March 2007	Telephone Number:	
Visit:	Incoming:	Outgoing: Return Call
NAME OF CONTACT:	Brown	
ORGANIZATION:		
ADDRESS:	Street:	
	Street 2:	
	City, State, Zip:	Nashville, Tennessee
E-MAIL:		
SUBJECT:	Wolf Creek Dam Emergency Measures EIS Scoping	

SUMMARY:

MR. Brown called to comment in response to the Wolf Creek Dam Emergency Measures EIS Scoping Letter that was published in the Tennessean Newspaper. Mr. Brown stated that there was no comparison of the environmental consequences associated with lowering the lake levels at Lake Cumberland and the consequences of losing the dam and the impacts associated with a dam failure. He said there are times when the environment must take a back seat to the safety of life and property.

C W Hall

Charles W. Hall

28 MAR 2007

Date

From:
To: Modification, Lake LRN;
CC:
Subject: personel input
Date: Thursday, March 29, 2007 8:15:44 AM
Attachments:

I agree with lower water levels if it will aide in both the quality and speed of the repair.

From:

To: Modification, Lake LRN;

CC:

Subject: Lake Cumberland Drawdown -- Comments

Date: Friday, March 30, 2007 8:33:36 AM

Attachments:

To whom it may concern,

Thank you for providing the opportunity for public comment on the issues surrounding the Lake Cumberland drawdown. Having followed events closely since the news broke I have been impressed with the Corps' handling of the issue and your efforts to keep the public involved and educated.

One of my concerns about the effects of this drawdown is the effect it will have on surrounding reservoirs. With the inevitable loss of traffic on Lake Cumberland those boaters/campers/etc are going to look at other nearby lakes for their recreation. Much time and effort has been spent extending ramps and reconfiguring docks to deal with the lower water at Lake Cumberland. My hope is that investments will be made in helping other nearby lakes deal with those who are migrating to other lakes while the dam is being repaired. Lakes like Dale Hollow & Barren River will likely see a surge in traffic. Are these lakes and their infrastructure prepared to deal with the increase?

I'm hopeful that many still visit Lake Cumberland and help sustain its local economy and enjoy what is still one of the largest lakes in Kentucky. I will still make a trip or two there this year as in the past. However, the reality is that the media has created an illusion that Cumberland is hardly worth visiting any more. This will impact the number of boaters that visit Lake Cumberland this year, regardless of what the realities may be.

Regards,

LaGrange, KY 40031

From: Gowins, John (EPPC DEP DAQ)
To: Modification, Lake LRN;
CC:
Subject: Wolf Creek Dam
Date: Friday, March 30, 2007 8:04:44 AM
Attachments:

Kentucky Division for Air Quality Regulation 401 KAR 63:010 Fugitive Emissions states that no person shall cause, suffer, or allow any material to be handled, processed, transported, or stored without taking reasonable precaution to prevent particulate matter from becoming airborne. Additional requirements include the covering of open bodied trucks, operating outside the work area transporting materials likely to become airborne, and that no one shall allow earth or other material being transported by truck or earth moving equipment to be deposited onto a paved street or roadway. Please note the Fugitive Emissions Fact Sheet located at http://www.air.ky.gov/homepage_repository/e-Clearinghouse.htm

Kentucky Division for Air Quality Regulation 401 KAR 63:005 states that open burning is prohibited. Open Burning is defined as the burning of any matter in such a manner that the products of combustion resulting from the burning are emitted directly into the outdoor atmosphere without passing through a stack or chimney. However, open burning may be utilized for the expressed purposes listed on the Open Burning Fact Sheet located at http://www.air.ky.gov/homepage_repository/e-Clearinghouse.htm

The Division also suggests an investigation into compliance with applicable local government regulations.

John E. Gowins, Supervisor
Program Evaluation Section
Program Planning Branch
Kentucky Division for Air Quality
(502) 573-3382 ext. 347
John.Gowins@ky.gov

From:

To: Modification, Lake LRN;

CC:

Subject:

Date: Friday, March 30, 2007 1:09:34 AM

Attachments:

I'm all for public safety, but it only makes since to me that if the dam would fail it would fail at 690, it would fail at 680 also. If in fact the problem is water seeping through the foundation under the dam. If the water level was left at 690 or even 685 the marina's especially Ali.1 would be able to operate with just a new ramp. I believe the corp is imposing undue heartache on alot of people for no reason. Just because you can. Thanks for the oportunity to express my view. Tim Scales 2806 w 500n marion In. PS I have experience dealing with the corp up here in Indiana. I have the ugly orange boundry marker in the corner of my yard the is the boundry of the Missisenewa resevoir. I tried to get the corp to remove it. It serves no purpose. The only people who need to know the boundry is me and the corp. The corp would not let me do that. Just because they can.

From:	Quincy Styke
To:	Modification, Lake LRN;
CC:	Barry Stephens; Jackie Waynick; Robert Foster;
Subject:	Tennessee Department of Environment and Conservation, Divisionof Air Pollution Control Comments
Date:	Friday, March 30, 2007 9:39:14 AM
Attachments:	

Colonel Roemhildt:

The Tennessee Department of Environment and Conservation's Division of Air Pollution Control has examined your notice in regard to repairs at the Wolf Creek Dam dated March 23, 2007 and has no comment to make.

Our position is based upon the fact that the dam itself is located in the state of Kentucky. As such, any dust or smoke that might originate during the repairs would likely be in Kentucky and not in our jurisdiction. We do note that there would be a likely reduction in hydroelectric power production and would ask that its loss be made up to the extent possible in non-fossil fuel power production.

Thank you for the opportunity to comment and best wishes for a speedy, successful repair.

Sincerely,

Quincy N. Styke III
Deputy Director
Division of Air Pollution Control

(615) 532-0562 voice

From:	
To:	Modification, Lake LRN;
CC:	
Subject:	ATTN: Chip Hall
Date:	Monday, April 02, 2007 11:45:54 AM
Attachments:	

This is regarding a post where the Corps is looking for local input regarding the Wolf Creek Dam.

Why would you ask now?????

The damage has been done !!!

I realize the safety of the people is foremost however economic impact is also very important. As the post indicates , "Yes, there will always be a Lake Cumberland" There will always be a Lake Cumberland, but how long will it take to bring it back? YEARS .
The total economic impact will be in the hundreds of millions of dollars.
The environmental impact will be off the chart.

Many engineers have stated that this entire project could have been done at 690' to 695'. Who decided that 680 was the magic number? Engineers have indicated that there are just a few more lbs of pressure at 695' Yes, it would cost more to perform this at 690 or 695 and maybe a little longer time frame. Wouldn't that be better rather than destroying the economy and costing marina owners millions ?
Your cost over runs are going to be much higher than the extra cost that would have been involved to begin with.

That is my input. Suggestions: Really don't have any because in my opinion, you have passed the point of no return.

From:
To: Modification, Lake LRN;
Subject: Island Road Ramp, Jabez, KY
Date: Wednesday, April 04, 2007 2:24:01 PM

Dear Mr. Hall-

I was appaled and horrifed at the destruciton I witnessed on Island Road Ramp near Jabez, Kentucky over the past several days. My family has been visiting this area of Lake Cumberland for over 40 years, owning a camp in that vacinity. It is my understanding that Alligator I is being moved near this location and the road to the two ramps at the end of this road are being prepared for this.

Very OLD trees now lay on the ground like toothpicks. It looks as if a bomb went off, to say the least. The beech, oak, and maple trees use to tower over the landscape bending with gently breezes. My family has seen pliated woodpeckers, wild turkeys, deer and numerous other wildlife in this area. It is a tragedy to bring such commercialism to such a beautiful area to accomodate several years of inconvience to Wolf Creek Alligator visitors. The sadest part is that it will never be the same again. Once this part of the landscape is opened up to the "public", it is forever changed. The towering trees can't be replaced. They are gone forever.

The phrase "Build it and they will come." is what is getting ready to happen and what a shame.

I would greatly appreciate it if you could provide me with the details of plans for this area. Where will all of the visitors park? Where will fuel be brought in, etc.? This is truly an environmental impact of the worst kind.

Sincerely,

From:
To: Modification, Lake LRN;
Subject: Wolf Creek Dam
Date: Monday, April 09, 2007 10:32:25 AM

Hi,
I read the article in the The Tennessean newspaper "Public Can Comment as Dam is Being Fixed". It says lowering the lake will result in "significant impact to fisheries and power generation. It doesn't even mention how many billions of dollars in damage would result down stream if the dam broke or how long it would take to clean the mess up. I cannot believe that the lake level was not lowered when it was apparent that there was a leak, but instead you rolled the dice for the people down stream!

I personally feel that if the dam would break after identifying that a problem exisited and not doing anything about it, the Arny Corps of Engineers should held responsible for all the damage incurred down stream!
I can be reached at: .

COMMERCE CABINET
KENTUCKY HERITAGE COUNCIL

Ernie Fletcher
Governor

The State Historic Preservation Office
300 Washington Street
Frankfort, Kentucky 40601
Phone (502) 564-7005
Fax (502) 564-5820
www.kentucky.gov

George Ward
Secretary

April 12, 2007

Lieutenant Colonel Steven Roemhildt
US Corps of Engineers
Nashville District
P.O. Box 1070
Nashville, TN 37202-1070

Re: Wolf Creek Dam/Lake Cumberland, Russell County, Kentucky

Dear Lt. Col. Roemhildt:

We have received your letter regarding the plans to immediately lower lake levels at Lake Cumberland, Russell County, Kentucky. These actions will result in extensive reaches of shoreline that have been submerged, or very infrequently exposed since the original filling of the reservoir, will be exposed for several months or more. There is a strong possibility that cemeteries, as well as other historic features associated with small towns, farms, and homesteads, and prehistoric archaeological sites are likely to be present and exposed with the lowering of water levels. A primary concern is archaeological resources, both historic and prehistoric, that if exposed would become targets for illegal collection of artifacts in violation of the Archaeological Resource Protection Act of 1979.

The National Historic Preservation Act requires Federal agencies to take into account the affect of their activities or undertakings on historic properties. I look forward to reviewing the Environmental Impact Statement addressing the issues set forth above. We strongly urge the US Army Corps of Engineers to work quickly and initiate archaeological surveys and possible excavation of the exposed areas in an effort to lessen the chance of destruction of potentially valuable resources and address potential adverse effects to historic properties eligible for listing in the National Register of Historic Places.

Should you have any questions, feel free to contact Lori Stahlgren of my staff at (502) 564-7005, extension 118.

Sincerely,

Donna M. Neary

Donna M. Neary, Executive Director
Kentucky Heritage Council and
State Historic Preservation Officer

Cc: Chip Hall

RUSSELL SPRINGS, KENTUCKY 42642

April 20, 2007

Mr. Chip Hall
Project Planning Branch
Department of the Army
Nashville District Corps of Engineers
P.O. Box 1070
Nashville, Tennessee 37202-1070

via Email and USPS

Re: March 23, 2007, request for public comments concerning the draw down of Lake Cumberland by the Army Corps of Engineers

To Mr. Hall:

As a resident of Russell County, Kentucky, and a landowner of property adjacent to Lake Cumberland, I am concerned about the Corps' stewardship, protection, and preservation of Lake Cumberland during the period of lower lake levels. Specifically, there is concern about having commercial boat docks and marinas move or expand to the detriment of the environment and natural resources heretofore well preserved by the Corps of Engineers.

It is my understanding that the approval of the site to which Alligator 1 is reportedly moving has been previously approved as a site for a boat dock and marina. I have heard that this site approval may have occurred as long ago as in the 1950s. I have been unable to find any documentation as to when, if ever, this site was approved, who approved it, what documentation was submitted, what criteria were used and how relevant and appropriate those criteria are today. A Freedom of Information Act request is being filed to help fill the void in available information due to lack of cooperation of the staff at the Nashville District Office with my attorney.

Economic Impact:

- It has been reported in the local media and public records that Alligator 1 will have debt obligations in the area of $7,000,000 after the move, including both the original debt and new debt to effectuate the move. It has also been reported that Alligator 1 at its present site had revenues of about $680,000

Page 1 of 5

and expects to lose 150 of its present 350 slips as a result of the proposed move. Even a cursory analysis would indicate that due to the relocation, the lake community runs a significant risk of having an economic failure which is clearly not beneficial to the Lake, to the economy or to the environment .

- The community surrounding Alligator 1, in and around Eli, has relied on Alligator 1 as a significant source of income and employment. Allowing the move of one of the largest sources of employment and income from this rural area will result in a serious negative economic impact to the local economy. Much of this local economy is based on the marina. There will likely be a substantial loss of employment in the Eli area as a result of Alligator 1 leaving the community. The community is largely dependent on tourist traffic from the two local docks. With one of those docks moving to the other side of Wolf Creek, near Jabez, about 30 miles away, there will be loss of jobs from Alligator 1, as well as numerous jobs from the support businesses including general stores, bait shops, motels and cabins.

- It is important that the Corps make certain that the relocation of Alligator 1 is a viable, feasible venture. The impact of having a dock in financial difficulty, with the possibility of foreclosure and/or abandonment, would clearly be adverse to the public interest and to protecting the Lake and its environment. The Corps should require some evidence of feasibility and/or require a performance bond from the Dock Owner to demonstrate his ability to operate a dock up to standards that assure public convenience and advantage and protects the environs from economic blight.

- The Corps should require that a viable business plan be submitted with adequate financial backing in order to protect against the adverse economic impact of both the dramatic change of the lake front and also the stress on the support businesses such as bait shops etc. nearby the present Alligator 1. Furthermore, the Corps should take into account the impact of a failure of the relocated Alligator 1 on the possible new businesses that may arise to support the marina in the new location. Because this part of the county is unincorporated, there is little political representation to protect the legitimate interests of the local residents, not to mention those persons who use this part of the lake. That role falls on the COE and as such the COE needs to be vigilant in protecting all of the interests listed in its notice and request for comments. Without the diligence of the Army Corps of Engineers and its appeal process, the only other avenue for redress are the courts.

- I understand that there is a new boat ramp to be constructed at the present site of Alligator 1 to enable the launching of larger boats, e.g., houseboats, and that there is an anticipated 6 feet of water available at that spot. If the launching capacity at Alligator 1 is being enhanced, what is the rationale for the moving of Alligator 1? Is there an element of the protection of the overall public good in the approval process? What is the approval process and what is the justification for the move? It seems odd that relocation of a boat ramp requires public notice (Public Notice No. 07-34 dated April 12, 2007)while there has been not public notice of relocation of a marina. Relocating the ramp involves the pouring of some concrete and construction of several feet of roadway, all occurring very near the existing boat ramp, with little disruption to the environment. Relocating a marina effects hundreds of people, the environment, the economy, the preservation of a tremendous natural resource, and yet there has been no evidence of public notice. Relocation of the marina will clearly have a large impact on employees, tourists, boat slip occupants, land owners, and others and therefore should be analyzed with at least as much scrutiny as a few yards of new concrete.

Environmental Issues:

- Since the Lake was built, nearly 60 years ago, the lower end of Wolf Creek has been preserved with very little disturbance. The area is rural with woodlands and is a favorite fishing location. The Corps has been robust and vigorous in its efforts to preserve the natural beauty of the Lake and its adjacent woodland. The Corps now appears to condone clear cutting timber for right-of-ways without appropriate analysis of public convenience and needs, and the impact of its actions.

- The two Alligator boat docks are presently adjacent to each other and consolidated in one general area. This configuration preserves the natural beauty of the protected environment from having boat docks spread about in locations that have been preserved since the Lake was constructed.

- Pollution from fumes, noise and light will be disturbing to the preserved area and those people who have chosen to live there. The present community boat dock has a limited number of slips and no lights, electricity or sewer facilities, and does not pose as significant a threat as a 350 slip marina.

- Providing for several hundred parking spaces will cause substantial disruption of the existing landscape. Providing infrastructure of roadways, electricity, water, and sewer will also cause substantial disturbance and disruption of the existing landscape, including the extensive removal of trees.

- There is a 75 acre farm adjacent to the proposed site that has been a wildlife habitat under the direction of the Kentucky Department of Fish and Wildlife's Habitat Improvement Program which would be impacted by the fumes, noise and light pollution of the relocated boat dock.

- Commercial areas on the Lake have been restricted to the Alligator 1 & 2 area and the State Dock/Jamestown area in the central part of lake since the Lake was built. To move commercial enterprises into this new area, heretofore maintained as a protected, natural area, is contrary to the Corps's efforts to preserve the Lake as a natural resource.

- For many years the Corps has prohibited the exploration and digging around exposed banks in order to preserve the natural environment. On the other hand, the Corps is planning to allow a major commercial dock, its fuel piers, its ship's store, its restrooms, and its 350+ boats and slip customers to relocate to a previously preserved section of Wolf Creek.

- The proposed location is prime fishing area. The site is immediately adjacent to a rock ledge that is 4/10 of a mile long and faces in a NNE direction. It is one of the few spots on Wolf Creek that can be fished when there is wind on the Lake.

- The relocation is approximately 30 miles by road from the present location. The relocation will be detrimental from an energy consumption standpoint as boat slip occupants in the area, as well as any employees who elect to keep their employment, will be required to travel a 60 mile or more round trip to the new location.

SUMMARY:

The lowering of the lake obviously causes significant disruptions in the economics of the whole region, not to mention the environment and other elements of what makes up the lake and its environs. However, just because there is this presumably necessary emergency, changes that would further impact the region need not necessarily be approved. Clearly from the available information, Alligator 1 could continue to function where it is, especially with the extension and enlargement of the boat ramp. My fear is that this move is being made without a full analysis of the negative impacts vs. the possible gains.

The possible, and by no means certain, gains appear to be only for the owners of Alligator 1. Those that would lose their livelihoods, such as workers who would lose their jobs and the owners and employees of support business in the area, and even those that would keep their jobs but have to drive the extra miles are not persons who gain. Nor is the environment an element that gains by changing a beautiful area to a developed area with all of the ambience that goes with this sort of development.

As a citizen of Russell County, the state of Kentucky and the United States of America I would expect that the Corps of Engineers would not allow such a change without properly reviewing all of the parameters available and properly weighing possible personal gain for a small number of business people vs. the impact on the environment and the surrounding economic environment. Right-of-ways have been clear cut and dozens of mature trees have been downed, with no evidence of the Corps conducting a thorough review and analysis of the economic or environmental impact of its apparent decision to allow relocation of a major marina.

Your serious consideration of my comments is appreciated.

Thank you,

cc:

Page 5 of 5

From:	Silas Mathes
To:	Modification, Lake LRN;
cc:	Karen Stachowski; Robin Cathcart;
Subject:	TN TDEC Div. of Natural Areas Comments for Wolf Creek Dam
Date:	Friday, April 20, 2007 10:48:35 AM
Attachments:	Wolf Creek Dam DEIS Scoping Comments.pdf 500 Foot Buffer Cumberland River Rare Species Entire State.xls

Please find the attached comment letter and rare species list from the Division of Natural Areas.

Thanks,

Silas

Silas Mathes
Division of Natural Areas
TN Department of Environment and Conservation
http://state.tn.us/environment/na/
silas.mathes@state.tn.us
voice: 615-532-0440
fax: 615-532-0046
7th Floor, L&C Annex
401 Church Street
Nashville, TN 37243-0447

STATE OF TENNESSEE
DEPARTMENT OF ENVIRONMENT AND CONSERVATION

Division of Natural Areas
7th Floor L&C Annex
401 Church Street
Nashville, Tennessee 37243
Phone 615/532-0431 Fax 615/532-0046

April 20, 2007

Chip Hall
Army Corps of Engineers, Nashville District
PO Box 1070
Nashville, TN 37202-1070

Re: Wolf Creek Dam Scoping Letter Public Notice

Dear Mr. Hall:

The Division of Natural Areas has reviewed the Wolf Creek Dam environmental impact statement scoping letter and offers the following comments regarding potential impacts to rare species.

The list below details rare species that have been observed in or adjacent to the Tennessee portion of the Cumberland River from the Kentucky state line downstream to Cordell Hull Dam. Aquatic habitats in this section of the Cumberland may be most immediately impacted by fluctuations in water levels due to management of the Wolf Creek Dam.

Scientific Name	Common Name	Federal Status	State Status	Global Rank	State Rank
Vascular Plant					
Carex gravida	Heavy Sedge		S	G5	S1
Carex hitchcockiana	Hitchcock's Sedge		T	G5	S1
Collinsia verna	Spring Blue-eyed Mary		E	G5	S1
Geranium robertianum	Herb-robert		S	G5	S2
Juglans cinerea	Butternut		T	G4	S3
Lesquerella globosa	Short's Bladderpod	C	E	G2	S2
Lonicera dioica	Mountain Honeysuckle		S	G5	S2
Invertebrate Animal					
Dromus dromas	Dromedary Pearlymussel	LE	E	G1	S1
Lithasia armigera	Armored Rocksnail			G3G4	S1S2
Villosa trabalis	Cumberland Bean	LE	E	G1	S1
Vertebrate Animal					
Ammocrypta asprella	Crystal Darter		D	G3	SX
Haliaeetus leucocephalus	Bald Eagle	LT,PDL	D	G5	S3
Myotis grisescens	Gray Bat	LE	E	G3	S2

1

For your use, we have also attached an Microsoft Excel spreadsheet listing rare species located within 500 feet of the Cumberland River and its impoundments throughout the state.

Should suitable habitat exist in areas affected by management activities at the Wolf Creek Dam, the Division asks the Army Corp of Engineers (Corps) to consider potential impacts to the above rare species and their habitats during preparation of the Draft Environmental Impact Statement. The Division also requests that the Corps consult with the Tennessee Wildlife Resources Agency (Rob Todd, 615-781-6572) as it may have additional information and regulatory requirements regarding aquatic fauna located in the Cumberland River.

Thank you for considering Tennessee's rare species throughout the planning of this project. For additional information regarding Tennessee's rare and endangered species or interpretation of Status or Ranks, please visit our website at http://www.state.tn.us/environment/na/. Should you have any questions, please do not hesitate to contact me at (615) 532-0440.

Sincerely,

Silas Mathes

Silas Mathes
Natural Heritage Data Manager

enclosure

Rare Species Observed Along the Tennessee Portion of the Cumberland River and Its Impoundments (500 Foot Buffer)
Division of Natural Areas, List Produced on April 20, 2007

Scientific Name	Common Name	Federal Status	State Status	Global Rank	State Rank
Nonvascular Plant					
Fissidens clebschii	Clebsch's Pocket Moss		S	GHQ	SH
Tortula fragilis	Fragile Tortula		E	G5	S1
Vascular Plant					
Amsonia tabernaemontana var. gattingeri	Limestone Blue Star		S	G5T3Q	S3
Apios priceana	Price's Potato-bean	LT	E	G2	S2
Arabis shortii	Short's Rock-cress		S	G5	S1S2
Aureolaria patula	Spreading False-foxglove		T-PS	G3	S3
Carex comosa	Bristly Sedge		T	G5	S2
Carex davisii	Davis' Sedge		S	G4	S1
Carex gravida	Heavy Sedge		S	G5	S1
Carex hirtifolia	Pubescent Sedge		S	G5	S1S2
Carex hitchcockiana	Hitchcock's Sedge		T	G5	S1
Carex muskingumensis	Muskingum Sedge		E-P	G4	SH
Cimicifuga rubifolia	Appalachian Bugbane		T	G3	S3
Clematis pitcheri	Pitcher Leather-flower		T	G4G5	SH
Collinsia verna	Spring Blue-eyed Mary		E	G5	S1
Dalea candida	White Prairie-clover		S	G5	S2
Dalea purpurea	Purple Prairie-clover		E	G5	S1
Diarrhena obovata	Beak Grass		S	G4G5	S1
Diervilla lonicera	Northern Bush-honeysuckle		T	G5	S2
Draba ramosissima	Branching Whitlow-grass		S	G4	S2
Eleocharis intermedia	Matted Spike-rush		S-PE	G5	S1
Elodea nuttallii	Nuttall's Waterweed		S	G5	S2
Elymus svensonii	Svenson's Wild-rye		E	G3	S2
Eriogonum longifolium var. harperi	Harper's Umbrella-plant		E	G4T2	S1
Erysimum capitatum	Western Wallflower	No Status	E	G5	S1S2
Geranium robertianum	Herb-robert		S	G5	S2
Hasteola suaveolens	Sweet-scented Indian-plantain		T	G4	S2
Helianthus occidentalis	Naked-stem Sunflower		S	G5	S2
Heteranthera limosa	Blue Mud-plantain		T	G5	S1S2
Hydrastis canadensis	Goldenseal		S-CE	G4	S3
Juglans cinerea	Butternut		T	G4	S3
Lesquerella globosa	Short's Bladderpod	C	E	G2	S2
Lilium canadense	Canada Lily		T	G5	S3
Lilium michiganense	Michigan Lily		T	G5	S3
Lonicera dioica	Mountain Honeysuckle		S	G5	S2
Lonicera prolifera	Grape Honeysuckle		E-P	G5	SH
Panax quinquefolius	American Ginseng		S-CE	G3G4	S3S4
Pedicularis lanceolata	Swamp Lousewort		S	G5	S1S2
Phacelia ranunculacea	Blue Scorpion-weed		S	G4	S2S3
Prenanthes crepidinea	Nodding Rattlesnake-root		E	G4	S2
Ranunculus flabellaris	Yellow Water-crowfoot		T	G5	S2
Sagittaria brevirostra	Short-beaked Arrowhead		T	G5	S1
Sagittaria platyphylla	Ovate-leaved Arrowhead		S	G5	S2S3
Solidago rupestris	Rock Goldenrod		E	G4?	S1
Stellaria fontinalis	Water Stitchwort		T	G3	S3
Symphyotrichum praealtum	Willow Aster		E	G5	S1
Talinum calcaricum	Limestone Fame-flower		S	G3	S3
Trifolium reflexum	Buffalo Clover		E	G3G4	S1
Vitis rupestris	Sand Grape		E	G3	S1
Invertebrate Animal					
Cumberlandia monodonta	Spectaclecase	C		G3	S2S3
Cyprogenia irrorata	Eastern Fanshell Pearly Mussel	LE	E	G1Q	S1
Dromus dromas	Dromedary Pearlymussel	LE	E	G1	S1
Epioblasma brevidens	Cumberlandian Combshell	LE	E	G1	S1
Epioblasma capsaeformis	Oyster Mussel	LE	E	G1	S1
Epioblasma obliquata obliquata	Catspaw or Purple Cat's Paw Pearlymussel	LE	E	G1T1	S1
Lampsilis abrupta	Pink Mucket	LE	E	G2	S2
Lithasia armigera	Armored Rocksnail			G3G4	S1S2
Lithasia salebrosa	Rustic Rocksnail			G3G4Q	S2
Obovaria retusa	Ring Pink	LE	E	G1	S1
Plethobasus cicatricosus	White Wartyback	LE	E	G1	S1
Plethobasus cooperianus	Orange-foot Pimpleback	LE	E	G1	S1
Pleurobema clava	Clubshell	LE	E	G2	SH

Pleurobema plenum	Rough Pigtoe	LE	E	G1	S1
Quadrula sparsa	Appalachian Monkeyface	LE	E	G1	S1
Villosa trabalis	Cumberland Bean	LE	E	G1	S1
Vertebrate Animal					
Acipenser fulvescens	Lake Sturgeon		E	G3G4	S1
Ammocrypta asprella	Crystal Darter		D	G3	SX
Aquila chrysaetos	Golden Eagle		T	G5	S1
Cryptobranchus alleganiensis	Hellbender	No Status	D	G3G4	S3
Cycleptus elongatus	Blue Sucker		T	G3G4	S2
Dendroica cerulea	Cerulean Warbler		D	G4	S3B
Haliaeetus leucocephalus	Bald Eagle	LT,PDL	D	G5	S3
Ichthyomyzon unicuspis	Silver Lamprey		D	G5	S2
Limnothlypis swainsonii	Swainson's Warbler		D	G4	S3
Macroclemys temminckii	Alligator Snapping Turtle		D	G3G4	S2S3
Myotis grisescens	Gray Bat	LE	E	G3	S2
Neotoma magister	Eastern Woodrat		D	G3G4	S3
Nerodia erythrogaster neglecta	Copperbelly Water Snake	No Status		G5T3	SNR
Notropis rupestris	Bedrock Shiner		D	G2	S2
Percina phoxocephala	Slenderhead Darter		D	G5	S3
Pooecetes gramineus	Vesper Sparrow		D	G5	S1B,S4N
Sistrurus miliarius streckeri	Western Pigmy Rattlesnake		T	G5T5	S2S3
Sorex longirostris	Southeastern Shrew		D	G5	S4
Thryomanes bewickii	Bewick's Wren		E	G5	S1
Typhlichthys subterraneus	Southern Cavefish		D	G4	S3
Zapus hudsonius	Meadow Jumping Mouse	No Status	D	G5	S4
Other (Ecological)					
Heron rookery	Heron Rookery			GNR	SNR

STATE OF TENNESSEE
DEPARTMENT OF ENVIRONMENT AND CONSERVATION
WATER POLLUTION CONTROL
401 CHURCH STREET
6TH FLOOR L&C ANNEX
Nashville, TN 37243

April 24, 2007

Chip Hall
Department of the Army
Nashville District, Corps of Engineers
P.O. Box 1070
Nashville, TN 37202

SUBJECT: Draft Environmental Impact Statement
Wolf Creek Dam, Russell County, Kentucky

Dear Mr. Hall:

Thank you for your recent request for comments on the above referenced emergency project in Russell County, Kentucky, relative to any potential environmental impacts or concerns the Division of Water Pollution Control (Division) may have.

As you stated in your letter, our main concerns with the lowered elevation in Lake Cumberland include the effects on water quality throughout the Cumberland River and the designated uses of the waterway including fish & aquatic life, livestock watering and wildlife, and irrigation.

The division's general concern about the construction project at Wolf Creek Dam is to ensure that best management practices and appropriate erosion prevention and sediment control measures are installed and maintained throughout the project's duration.

Please understand that there may be other regulatory programs applicable to this project that are administered by other divisions of the Department of Environment and Conservation. The applicant is responsible to determine all regulatory programs that are applicable to this project.

We appreciate the time and effort that the Corps of Engineers have devoted to this project, and we are aware of your efforts to work with the public, the State of Tennessee, Tennessee Valley Authority, and the numerous Public Utilities along the Cumberland River in order to devise a plan of minimal impact to water quality and public health and safety.

If you have any questions regarding these comments, please contact Rob Howard at (931) 432-7632.

Sincerely,

Regan W. McGahen

Regan W. McGahen
Environmental Specialist
Division of Water Pollution Control

RWMC/jaw

cc: File
Karen Stachowski, TDEC
Rob Howard, Water Pollution Control Manager, Cookeville EFO

From:
To: Modification, Lake LRN;
Subject: Wolf Creek Dam
Date: Wednesday, April 25, 2007 8:25:31 AM

I just read the latest info from an independent study stating the dam could break with a 5 year period. Why has the lake not been reduced by 70ft as recommended? To sit there and do nothing is totally ridiculous. I assume you will picking up the tab for all the damages since you know there is a problem and you are not addressing the issue.

United States Department of the Interior

FISH AND WILDLIFE SERVICE
446 Neal Street
Cookeville, TN 38501

May 2, 2007

Mr. Chip Hall
Project Planning Branch
U.S. Army Corps of Engineers
P.O. Box 1070
Nashville, Tennessee 37202-1070

Re: FWS #07-FA-0542

Dear Mr. Hall:

We are in receipt of your notification of intent to prepare a draft environmental impact statement to address the potential impacts of completed and proposed actions associated with emergency repairs to Wolf Creek Dam, Russell County, Kentucky. Our office is responsible for activities within the State of Tennessee and our comments and recommendations are confined to potential impacts of your proposal on the resources of the Cumberland River therein.

We have previously discussed with Nashville District Environmental staff completed actions to reduce the elevation of Lake Cumberland to 680 feet AMSL. As we advised, emergency consultation procedures should have been pursued by the District pursuant to 50 CFR 402.05 prior to initiating the drawdown. This section of the Endangered Species Act allows Federal agencies to incorporate endangered species concerns during response to an emergency without obstructing or delaying decisions made to protect human lives. We have discussed these alternative consultation procedures with the Environmental staff and recommend that they be followed in the future whenever applicable and appropriate.

Potential impacts of both the completed drawdown and future operation and repair activities upon the Cumberland River will likely center around water quality and quantity issues directly related to tailwater discharges. Deviations from normal regulated flow patterns and typical temperature and dissolved oxygen regimes could adversely impact aquatic resources. This will particularly be the case given the District's decreased ability to regulate the quantity and quality of water available for tailwater discharges. We were pleased to learn during recent discussions with Planning Branch staff that detailed water quality monitoring and predictive computer modeling are currently being implemented to identify issues as they evolve and predict and avoid potential problems before they arise.

The receiving waters of the Wolf Creek Dam discharge are predominately impounded within additional downstream reservoirs. For this reason, rare aquatic species, primarily listed endangered freshwater mussels, occur at relatively few locations. Most remnant mussel populations are confined to areas that continue to experience significant flow as the result of tailwater releases. As a consequence of impoundment and consistent low water temperature, these specimens are believed to no longer reproduce and are dominated by older individuals that were present when the system was impounded. Consideration has been given in recent years to removal of these specimens for use in propagation efforts, and in this regard their potential value to the survival of their species remains significant. We note that drastic water quality changes that may be predicted to occur as a result of the subject proposal may warrant removal of these remnant populations to prevent the loss of this genetic pool. We request that the Nashville District keep the Fish and Wildlife Service and the Tennessee Wildlife Resources Agency apprised of actual and predicted water quality conditions in order to allow sufficient time to recommend and implement potential remedial actions to protect rare species within the Cumberland River system.

Potential adverse impacts may also occur to more common aquatic resources adapted to cold tailwaters or existing warmwater impoundments. Many of these species, particularly fish species, are of high recreational importance and should be considered during the District's impact evaluation. However, impacts to these species would likely be temporary, and populations will ultimately recover to pre-project status.

Again, we applaud the Nashville District for its proposed impact monitoring and prediction efforts related to this emergency situation. Please keep our agency advised regarding your findings, particularly in regard to predicted future water quality changes, in order that we may assist with impact remediation, especially for endangered species.

Sincerely,

Lee A. Barclay

Lee A. Barclay, Ph.D.
Field Supervisor

xc: Robert Todd, TWRA, Nashville, TN

COMMONWEALTH OF KENTUCKY
OFFICE OF THE GOVERNOR

ERNIE FLETCHER
GOVERNOR

700 CAPITAL AVENUE
SUITE 100
FRANKFORT, KY 40601
(502) 564-2611
FAX: (502) 564-2517

May 6, 2007

Steven J. Roemhildt, P.E.
Lieutenant Colonel
Department of the Army
Nashville District, Corps of Engineers
Post Office Box 1070
Nashville, TN 37202-1070

Dear Colonel Roemhildt:

The state agencies of the Commonwealth of Kentucky received your March 23, 2007, request for input during the process of developing a Draft Environmental Impact Statement (DEIS) for actions at Wolf Creek Dam and Lake Cumberland under the National Environmental Policy Act (NEPA). We appreciate the opportunity to provide comments during the NEPA process.

To expedite the process, we have solicited comments from every state agency involved in the Wolf Creek Dam and Lake Cumberland activities and consolidated them as one response from the Commonwealth of Kentucky. The health and safety of our citizens remains the top priority of the Commonwealth.

The emergency declaration by the Corps, the actions at Wolf Creek Dam and the associated modification of the lake level have many real and potential health and safety, environmental and economic impacts. We request that you consider these comments as you develop the DEIS and consider not only the environmental impacts, but also the impacts to aesthetics, business, economy, recreational use, and water availability for industrial, private, and municipal use and electrical generation.

My office, through an Executive Order, has already taken some steps to address a few of the impacts already being felt by communities in the Lake Cumberland region. We look forward to continuing to minimize impacts of actions taken by the Corps and assist you in implementing a plan that also minimizes the risk to the integrity of the dam.

Sincerely,

Ernie Fletcher

Ernie Fletcher

COMMONWEALTH OF KENTUCKY COMMENTS
ACTIONS AT WOLF CREEK DAM AND LAKE CUMBERLAND

Governor Ernie Fletcher established a work group in January 2007 to develop a plan to reduce the potential impacts of actions at Lake Cumberland and Wolf Creek Dam and provide a coordinated response to needs in the area. The work group is comprised of agencies with expertise in areas affected by the actions at Wolf Creek Dam. The primary concerns are the safety of the citizens, the integrity of the Wolf Creek Dam, the protection of Lake Cumberland, and the economic impact on local businesses. The desire is to reduce the risk of dam breech while minimizing adverse impacts.

By letter dated March 23, 2007 the Army Corps of Engineers solicited comments in preparation for developing a Draft Environmental Impact Statement as required by the National Environmental Policy Act for actions at Wolf Creek Dam and Lake Cumberland. The request from the Corps acknowledges the impacts of these actions are broader than just environmental and the following comments reflect these impacts as a result of the Army Corps of Engineers' lowering the water level of Lake Cumberland to 680 feet above sea level. Should the Corps decide to lower the water level further, this analysis may change. With that in mind, this document is the collective response from Commonwealth of Kentucky state agencies. The following comments should be considered when evaluating impacts of proposed activities at Wolf Creek Dam and Lake Cumberland and developing the Draft Environmental Impact Statement.

Commerce Cabinet

The tourism economy around the lake is very dependent on the boater traffic and water recreation. There is little other tourism development in the immediate area.

The tourism impact would be felt in four counties that surround Lake Cumberland – Clinton, Pulaski, Russell, and Wayne. The combined economic impact in 2005 from tourism in these counties as measured by the Travel Industry of America, a leading tourism research firm, is over $150 million with a growth trend of approximately 7.5% per year. Lake recreation is the primary draw to this area which is billed as the "houseboat capital of the world."

At the current water elevation (680 ft):

1. Ramp extensions are needed to reach the lowered water level. Not all ramps are suitable for extending.
2. Small private businesses near the larger boat ramps are impacted by the perception that the lake water level is too low for normal fishing and recreational boating activity. These businesses include overnight accommodations, boat repair, boat storage, restaurants, campgrounds, convenience stores and other similar businesses. The negative effects include reduction of jobs and financial losses to the business owners.
3. Impact to marinas – several marinas are unable to continue operation at their current location due to lower water depth. Significant costs will be incurred to move these marinas to deeper waters.

If water levels are lowered below 680 ft, further extension of boat ramps may be impossible, thereby reducing or eliminating lake access. Fewer marinas would remain operational without relocating.

Kentucky Department of Fish and Wildlife Resources

1. Cold Water and Warm Water Fisheries & Designated Uses

- The tailwater fishery has a $7.1 million annual economic benefit. The 75 miles of the river below Wolf Creek Dam provides cold-water aquatic habitat necessary to sustain this fishery. Lower lake levels (<680 elevation) could eliminate this coldwater fishery and a warm-water fishery will not develop in this area due the periodic release of cooler water during the construction period.

- The loss of cold water zones in the lake and flow pressure from the drawdown could negatively impact trout production at the Wolf Creek National Fish Hatchery which is dependent upon lake water, cold water temperatures, and water pressure. Approximately 800,000 trout are produced annually at this hatchery to stock the entire state.

- Trophy walleye and striped bass populations could be eliminated due to the loss of critical cold water habitat. Though sustained by stocking programs, both species require oxygenated cold-water habitat.

- Impacts to fisheries will not be limited to cold-water species. Valuable shallow water zones critical for fish spawning will be diminished, potentially impacting warm-water fish production (bass, crappie and panfish).

- There is a cost to improve shoreline and aquatic habitat while the lake has been lowered. Shoreline and aquatic habitat improvements should be considered during dam reconstruction. Artificial fish attractors, permanent vegetation plantings, and mud-flat seeding would help minimize short-term losses and help to recover losses over the long-term.

2. Additional Economics and Recreation

- Access to the lake by boaters and fishermen is affected due to the reduction of the number of ramps to the lake. There are 60-70 boat ramps and access points on Lake Cumberland. Approximately 90% of these will be impacted. The emergency provisions invoked on January 19, 2007 by the Corps will help expedite the extension of Corps owned boat ramps. The loss of use for non-Corps owned ramps and funding to make them functional at lower water levels needs to be addressed.

- Lake drawdown to the 680 ft. elevation results in the loss of 13,000 surface acres, which could be perceived to reduce boating and fishing recreational opportunities.

Kentucky Department of Parks

The lower lake elevation will impact revenues at the Lake Cumberland State Resort Park from anticipated lower visitation. Additionally, the Department of Parks generates revenue from a leased marina that is impacted by a lower level of the lake.

Cabinet for Economic Development

Since the Corps announced that the lake levels would be lowered to an elevation of 680 feet above sea level we are concerned that the lowering will negatively impact the economy of the region, which benefits from an estimated 4.7 million Lake Cumberland visitors a year. In 2005, visitors had an estimated economic benefit of $150 million dollars to the region as documented by the Travel Industry of America. This tourism economy is made up of a multitude of small & micro-business enterprises which includes:

1. Marinas
2. House Boat Manufacturers
3. House Boat Repair Shops
4. Bait and Tackle Shops
5. Cabin and Hotel Lodges
6. Country Stores
7. Eateries and Diners
8. Resort Proprietors and Vacation Home Builders
9. Recreation Watercraft Dealers, etc.

The actions taken by the Corps to correct the situation related to the Wolf Creek Dam will have significant economic consequences to the many businesses within the Lake Cumberland region. The following comments represent our assessment of the impact to the small & micro-enterprise business owners who attended focus group meetings with the Kentucky Cabinet for Economic Development:

1. This activity will directly disrupt the normal flow of the local economy that has historically revolved around a robust recreational economy and infrastructure.

2. Small & micro-enterprise business owners have fewer resources to recover from such a significant and prolonged "Emergency Action" by the Corps and impact will be significant and potentially long-term on this segment of the economy.

3. There could be a net loss of jobs for the region. The disruption of cash flow will require many impacted businesses to make significant hiring decisions.

4. There will be increased pressure on local, state and federal agencies to provide immediate and long-term assistance for individuals and families impacted by job loss and job reductions.

5. Population figures may be adversely impacted as employment opportunities diminish in the region and job seekers are faced with the prospects of seeking employment further away or moving altogether.

6. The area has successfully capitalized on the recreational opportunities created by the formation of Lake Cumberland; however this action will slow down or may reverse the economic momentum that has been built up over the past forty-five (45) years.

The actions may affect the ability to attract new industry into the region. If there is a perception of a loss of quality of life, this will impact future growth. If there is a real or even perceived loss of available water to serve future economic growth there will be a substantial chilling effect on business attraction.

Governor's Office for Local Development (GOLD)

Following the Corps decision to lower the level at Lake Cumberland to 680 feet above sea level in January, GOLD and the Kentucky Infrastructure Authority (administratively attached to GOLD) have worked with several cities, counties and other entities to facilitate plans to ensure municipalities with water intakes and discharges in Lake Cumberland keep a reliable, safe level of service. These plans have also involved contingencies should the Corps decide to lower the lake further, or an unforeseen emergency or poor weather conditions cause the lake level to drop.

Two letters from the Corps dated February 9 and March 23 of this year have instructed local officials in the affected area to be ready for the possibility of the lake being lowered to 650 feet above sea level by December, 2007.

More than 200,000 Kentuckians rely on Lake Cumberland as their source of drinking water. Because the Corp's authorized mission does not include water resource assistance, it was imperative Kentucky take action to ameliorate the threat of the loss of drinking water. On April 13, 2007 Governor Fletcher signed an executive order establishing a funding framework to address immediate public safety concerns and other harmful effects caused by the lowering of Lake Cumberland and safety concerns with Wolf Creek Dam. Governor Fletcher has authorized up to $25 million in emergency funding and has directed all agencies of state government with potential existing programs that could aid the affected communities to provide assistance to GOLD.

Environmental and Public Protection Cabinet (EPPC), Department for Environmental Protection, Division for Air Quality

Actions must be in compliance with requirements related to fugitive emissions and open burning as described in 401 KAR 63:010 and 401 KAR 63:005 and compliant with any applicable local

government regulations. The Division for Air Quality has developed a Fugitive Emissions Fact Sheet and an Open Burning Fact Sheet at the following locations.
http://www.air.ky.gov/homepage_repository/e-Clearinghouse.htm
http://www.air.ky.gov/homepage_repository/e-Clearinghouse.htm

EPPC, Department for Environmental Protection, Division of Water

1. Intake Relocation. With the potential to decrease the pool elevation to 650 feet, all 7 public water systems that withdraw water from Lake Cumberland would lose the ability to withdraw sufficient water. Potential issues associated with relocating water intakes include securing funds, locating piping, pumps and other material, moving power lines, working on the exposed lake bottom and the short time frames for completing the work. In the event of water levels below 673 feet, approximately 200,000 people could be without drinking water, sewage treatment plant operations or fire protection.

2. Discharges and Runoff. As water levels drop, there may be less water available for dilution of pollutants entering the lake, from either controlled sources such as wastewater plants or non-specific points such as agricultural runoff. Increased pollutants may result in increased treatment at water plants. In order to meet permit limits, additional treatment may be necessary, wastewater discharges may need to be moved to another location in the lake, to a lateral field or to another treatment plant. If outfalls are not moved there is the potential for discharge of wastewater on dry banks of the lake.

3. Increased Costs.

   A. Power Costs. Power plants that have to draw water from a lower elevation will incur higher cost to pump water against a higher head pressure. Relocated raw water intakes with longer raw water transmission mains could result in cavitation in the mains if the pumps pull in air during a drop in water level. Cavitation can result in a break in the line.

   B Treatment Costs. Treatment chemical costs will increase with the need for more water treatment and additional chemicals.

      - Manganese. Lower intake ports for water systems could result in elevated raw water manganese levels since water closer to the bottom of the lake is typically higher in manganese.

      - Taste and Odor. Water from lower levels in the lake, particularly below the thermocline, has less oxygen and compounds would be in a more reduced chemical state that can create taste and odor problems such as the "rotten egg" smell of sulfides.

      - Increased Eutrophication. Algae and algal by-products will result in increased oxidant and coagulant treatment, filter washing and potentially non-compliance with treatment byproducts (THMs, HAAs, turbidity). Wastewater discharges higher in the water column will also allow nutrients to be more available for algae growth and reproduction.

- Turbidity. Lower lake levels would expose more of the bank area that would be prone to increased sediment runoff resulting in elevated turbidity levels. Higher turbidity translates to additional chemicals for treatment and increased filter washing. Water intakes located in a cove where the drop in water level would be more drastic could also result in higher turbidity in the raw water.

4. Construction Compliance. Construction activities associated with the Wolf Creek Dam and Lake Cumberland stabilization project must be in compliance with the stormwater management requirements of 401 KAR 5:0650, Section 12. General storm water permit coverage is required for construction activities that disturb one (1) or more acres. One of the requirements for coverage is to prepare and implement a storm water pollution prevention plan (SWPPP) prior to the start of construction. The SWPPP should be kept on-site and available to compliance staff when inspections are performed. Also, any contractors working under the permit, should have signed off on the SWPPP. It is requested that the EIS include the following elements relative to the SWPPP:

   A. Identify specific Best Management Practices (BMPs) to be utilized to ensure minimal impact to water quality due to runoff from construction activities.

   B. Identify the person(s) responsible for implementing BMPs and ensuring that BMPs are followed.

5. Groundwater.

   A. Wells. Lowering the pool elevation in Lake Cumberland impacts wells near the lake. Three communities in Wayne and Pulaski Counties that rely solely on domestic wells or cisterns for water supplies have been identified as either impacted or potentially impacted: Rocky Hill Road (Wayne County) has two domestic wells dewatered, which serve 21 people (8 homes) and two domestic wells experienced decreased yield, Diamond Acres (Pulaski County) had one domestic well with decreased yield, and Jasper Bend (Pulaski County) had two domestic wells with decreased yield. Further lowering of Lake Cumberland will undoubtedly impact more domestic water wells, causing further water shortages. Both Pulaski County communities have a significant number of seasonal residences (50-60%) using domestic wells that could not be assessed.

   B. Sinkholes. With lower levels in Lake Cumberland, there is an increased potential for sinkhole collapse. The highest potential for sinkhole collapse is in areas where the soil has been completely saturated (i.e. submerged beneath the lake). Any collapses in the upland are most likely to occur within existing deeper, larger sinkholes.

6. Impacts from Houseboats. With lower pool elevation higher levels of bacteria may be found with less water available for dilution and in areas of high houseboat density and the possibility of more houseboats discharging into lake if unable to access pump-out facilities.

7. Lower Water Quality.

   A. Loss of fish habitat at lower pool elevations is a concern, including spawning areas for black bass. Loss of cold water habitat in the lake is possible as large volumes of warmer water flow into a lake with a lesser volume of cold water. Normal releases through penstocks will be warmer as they will be much higher in water column than previously, resulting in loss of cold water aquatic habitat downstream of the dam. Necessary release of large volumes of warm water through penstocks to keep lake levels down will cause loss of cold water aquatic habitat. Warm water habitat will also not be able to be established with the periodic releases of cold water.

   B. Lower flow-through associated with increased retention time because of less hydropower generation and resulting decrease of flow through the lake affects water quality.

   C. Drought conditions or further lowering of lake will result in lower flow (mostly from bottom sluice gates), causing loss of flow and habitat and temperature increases downstream of the lake as low volume of water is heated by summer conditions.

8. Sensitive Populations. The trout fish hatchery located adjacent to the dam will have difficulty obtaining a supply of water that adequately meets temperature and oxygen needs.

   A. The functionality of the streams that feed the lake will change. Some formerly impounded portions will be free-flowing. If allowed to be free-flowing for 7-10 years, these streams will tend to take on flowing stream characteristics. Flora and fauna of free-flowing streams will become established only to be forced back upstream or eliminated when impoundment occurs. This could affect populations of the ashy darter in the Rockcastle River and South Fork Cumberland River and dusky tail darter in the South Fork Cumberland River.

   B. Kentucky Department Fish and Wildlife Resources is initiating a study to re-establish lake sturgeon in Lake Cumberland. The lake draw-down may interfere with success of this project.

   C. With low water levels below the dam, mussel surveys should be completed to determine the existence of mussel beds in this portion of the Cumberland River.

EPPC, Department of Public Protection, Office of Financial Institutions

Loss of tourism dollars could have long-term economic impacts on the affected communities. The primary concern of state chartered banks in the area is a severe economic downturn in the region and this affect on the communities that they serve. A breach of the dam would potentially have an effect on essential banking services.

There are costs associated with failure of the dam. Sources of financing disaster recovery following a significant failure of the dam should provide for rebuilding infrastructure, homes and businesses.

EPPC, Public Service Commission

The principal concern within PSC's jurisdiction related to actions at Lake Cumberland is the impact on the East Kentucky Power Cooperative (EKPC) Cooper Generating Station. The lowering of the lake would affect the station's generating capacity during the summer even with planned auxiliary water supply. The reduced capacity could force EKPC to purchase more costly power on the open market in the event that the South East Power Administration (SEPA) is unable to deliver contracted amounts of power due to output reductions from Wolf Creek Dam and other hydroelectric facilities on the Cumberland River or its tributaries. Big Rivers Electric Cooperative, which also purchases power from SEPA, could be similarly affected.

Additional costs incurred by EKPC or Big Rivers as a consequence of the lowered water level in Lake Cumberland will ultimately be passed on to the customers of the utilities. This will have a widespread and direct economic impact.

Several water utilities within the PSC's jurisdiction could experience similar economic impacts that could be passed on to their customers. Utilities are forced to extend their water supply intakes and a number of water districts purchase water from utilities that have to extend their intakes due to the lower water level. These costs would likely be passed on to the customers.

Kentucky State Nature Preserves Commission

The Kentucky State Nature Preserves Commission (KSNPC) encourages the U.S. Army Corps of Engineers, during the planning process for repairing Wolf Creek Dam, to consider looking at the Cumberland River resource in more of an ecosystem context. Historically the Cumberland River supported one of the richest freshwater mussel communities in the world. While many species were eliminated as a result of impoundment of the river, others are being adversely affected by the cold hypolimnetic water release operation below the dam that has been put into place for the trout fishery.

In reviewing the planned repairs of the dam, we would recommend the Corps consider implementing infrastructure for managing water releases in a manner that would enhance or restore conditions for the native species. Such a design could be something like providing a dedicated cold water intake to Wolf Creek Fish Hatchery that would allow continued trout production as well as providing more varied water temperature releases for the native mussels and fishes.

Cabinet for Health and Family Services, Department for Public Health

We anticipate an increase in the need for financial, social, and mental support services as a result of an economic hardship on many families because of the decline in tourism dollars. A long term loss of electricity or the availability of water for human consumption would have a significant impact on residents in the area and force many to seek shelter and or health care services elsewhere. Furthermore, a material breach of the dam could pose a potential immediate threat to life for some and would have a protracted impact on the residents in the community.

Appendix D

Responses from 45 day Review of Draft EIS

STATE OF TENNESSEE
DEPARTMENT OF ENVIRONMENT AND CONSERVATION
WATER POLLUTION CONTROL
401 CHURCH STREET
6TH FLOOR L&C ANNEX
NASHVILLE, TN 37243

October 16, 2007

Mr. Chip Hall
Attn: CELRN-PM-P
Department of the Army
Nashville District, Corps of Engineers
P.O. Box 1070
Nashville, Tennessee 37202-1070

SUBJECT: Wolf Dam/Lake Cumberland
Draft Environmental Impact Statement (DEIS)

Dear Mr. Hall:

Thank you for your recent request for comments on the above referenced DEIS project in Russell County, Kentucky, relative to any potential environmental impacts or concerns the Division of Water Pollution Control (Division) may have.

Our main concerns with the lowered elevation in Lake Cumberland include the effects on water quality throughout the Cumberland River and the designated uses of the waterway including fish & aquatic life, livestock watering and wildlife, and irrigation.

The division's general concern about the construction project at Wolf Creek Dam is to ensure that best management practices and appropriate erosion prevention and sediment control measures are installed and maintained throughout the project's duration.

Please understand that there may be other regulatory programs applicable to this project that are administered by other divisions of the Department of Environment and Conservation. The applicant is responsible to determine all regulatory programs that are applicable to this project.

We appreciate the time and effort that the Corps of Engineers have devoted to this project, and we are aware of your efforts to work with the public, the State of Tennessee, Tennessee Valley Authority, and the numerous Public Utilities along the Cumberland River in order to devise a plan of minimal impact to water quality and public health and safety.

If you have any questions regarding these comments, please contact Rob Howard at (931) 432-7632.

Sincerely,

Regan M McGahen (jaw)

Regan McGahen
Environmental Specialist
Division of Water Pollution Control

cc: File
Mary Parkman, TDEC - Office of General Counsel
Rob Howard, Water Pollution Control, Cookevillr EFO

From:	Ray Wilder
To:	Modification, Lake LRN;
cc:	Ann Cates;
Subject:	Lake Cumberland and subsidence
Date:	Sunday, October 21, 2007 12:00:10 PM

I live 1.8 miles from Lake Cumberland, near Jamestown Kentucky. Lately I have noticed small fissures opening up in my lawn. Some of them may be due to the dry Summer, but I suspect they are also due to the low level of water in Lake Cumberland causing a lowering the ground water level in this area.

The subsurface in this area is layers of stratified rock that is probably filled with water from the lake. As the lake water slowly leaves that strata we may see massive ground settling.

This area was built up while the lake level was at its normal high and the ground water it forced into the subsurface strata supported its structures.

I am concerned that continued falling ground water level may affect the foundation of my home, and other homes in this area.

Has this matter been addressed by the Corps of Engineers?

Yours truly, Ray Wilder

38 Jordan Ct
Jamestown Ky. 42629
270-566-4343
buckskin@mac.com

From:	dcorneli@fuse.net
To:	Modification, Lake LRN;
Subject:	Comment on Lake level
Date:	Tuesday, October 23, 2007 7:04:12 PM

I am a property owner joining the Lake Cumberland boundary near Jamestown. We are there because of the beautiful lake and associated activities. We share in a community dock.
I understand there is no solution that meets all the needs of all the stakeholders of the lake area. The safety of all people and property down stream of the Dam must take president at a "reasonable level of risk"

Our experience on the lake this year shows fewer visitors have come, in part to the lower lake level. Even with the extended ramps at Jamestown, launching a boat of any size has greater risk to person and property than when the lake was even 10 feet higher . As a property owner in compliance with COE guidelines on what we can do with our property as it effects the lakes appearance I must point out that the 680 ft level substantially detracts from the appearance of the lake.

"Reasonable risk" is only definable by you the COE in that you understand the actual failure possibility of the Dam.

My request is that if "reasonable risk" can be achieved at a higher level 690 or 700' I would encourage that to be the interim level until higher level becomes prudent. As part owner in the Community dock holding at any given level is an advantage as compared to a continually variable level.

Thank you for requesting input.

From:	Carol M
To:	Modification, Lake LRN;
Subject:	Comments
Date:	Tuesday, October 23, 2007 1:55:16 PM

I have been studying all the documents that have been released. I am glad that you are finally taking a look at Cumberland County and the affect the dam breaking would have on this county.

Questions...

When you do replace the dam, do you intend to put it in a different place? It would seem to me that there would be a better place to tie it into more solid rock.

Are you going to make it so that the 'bow' of the dam head upstream like a stone arch bridge does? The more pressure on it...the tighter it gets. It seems to me that this one (and where the weakest spots are are curved downstream, not upstream as you might think). You might want to look at the Hoover Dam....

Thanks for all the hard work you do to keep us safe!

Carol Merrill

From: Sherlene Gadberry
To: Modification, Lake LRN;
Subject: Aligator 1
Date: Friday, November 02, 2007 12:36:02 PM

Please consider the importance of natural habitat and Native American findings on Cave Springs before moving a boat ramp

----

Sherlene Gadberry

Kentucky Leadership Center

17500 Highway 196

Nancy, KY 42544

(270) 866-4215

Fax: (270) 866-4275

sgadberr@uky.edu

From: Michael Hester
To: Modification, Lake LRN;
Subject: Lake Levels
Date: Tuesday, November 06, 2007 5:11:31 PM

To Whom It May Concern:

The lake levels in our community have been a welcomed change. We have more area for parking, the ramp (although temporary) has less of an incline, and the "beach area" makes for a better recreational area. The only drawback in the ramp is that the gravel has been moved around causing difficult launching at the end of the season due to the lake dropping even further. We have a temporary anchor holding our dock out past the existing anchors. The lake level change has helped our community become closer as we shared more time at the shore rather than somewhere on the lake. It has also reduced the crowding on the lake due to the negative press. I am sure if you ask the folks in our side of the lake you will find that it was a good thing. I would like to see the level remain as it did most of the summer. We do though need a concrete ramp. I noticed that some of the ramps were getting concrete extensions. Any chance we can get one here in Cub Creek? Please let me know. I also understand there is a generator replacement project taking place at the dam as well. What are the details on that? The only scare we had is when the Conversation Officer for our area came down to the dock and warned us not to drive our ATVs on the shore past the parking area. What a shame as there are lots of areas to explore.

THAnks!

Michael Hester

Service Manager-National Accounts

Office (513)761-6000 ext 1170

National (800)540-6707

Mobile (513)615-2182

Fax (513)679-6191

From:	Sanger, Daniel A (GE Infra, Energy)
To:	Modification, Lake LRN;
Subject:	Lake modification
Date:	Thursday, November 08, 2007 4:01:17 PM

To whom it may concern,

Here are my thoughts concerning the lake level of 680 and the rumored raising to 690.

If you are raising the level to 690 for political reasons, please don't. Raising the level anything less than to 700 would severely impair out ability to have access to the lake in Cub Creek. At 690 the lake level would be just to the end of the public ramp (in Cub Creek) and would not provide any access as there is no alternative route to use in Cub Creek. This ramp provides an easy access to many of the area fisherman, not to mention the recreational users during the months of May through November.

We, as a state have spent a considerable amount of money preparing for this level, that we were told would be for at least 5 years. Let us not consider the money a waste.

Further concerns are on the stability of the Dam during the repair process. We've been told many times that the level needs to be 680 for the duration and after this first year we all have adjusted, including the marinas. Are the repairs going that well that the dam can now withstand the pressures that present itself at 690? What about 700 then?

Regards,
Dan Sanger
Nancy, KY

COMMERCE CABINET
KENTUCKY HERITAGE COUNCIL

Ernie Fletcher
Governor

The State Historic Preservation Office
300 Washington Street
Frankfort, Kentucky 40601
Phone (502) 564-7005
Fax (502) 564-5820
www.kentucky.gov

George Ward
Secretary

Donna M. Neary
Executive Director and
State Historic Preservation Officer

November 14, 2007

Mr. William Barron
Nashville District, Corps of Engineers
PO Box 1070
Nashville, TN 37202-1070

Re: Wolf Creek Dam/Lake Cumberland – Draft Environmental Impact Statement

Dear Mr. Barron:

The State Historic Preservation Office has reviewed the above referenced draft Environmental Impact Statement. The most resent archaeological assessment field survey conducted after the drawdown has revealed that numerous recorded and previously unrecorded archaeological sites, both historic and prehistoric are present within the project area. Eleven of the 72 archaeological sites examined during the course of this project were determined to be potentially eligible for listing in the National Register of Historic Places. In addition to these sites, maintaining Lake Cumberland at its current lower pool height of 680 feet has the potential to impact several hundred other archaeological sites that have yet to be documented by professional archaeologists. All of these historic properties will be adversely effected by continued exposure to erosion and extensive collecting and looting. The latter is a violation of the Archaeological Resources Protection Act.

With this in mind, we recommend that the immense potential loss of significant cultural information be included within the Cumulative Impacts of the Environmental Statement. Once these resources disappear, through erosion or looting, they are gone forever and part of our history is irrevocably lost.

We look forward to working with the Corps of Engineers, the Advisory Council on Historic Preservation, relevant Native American tribes, and other consulting parties to develop and implement a Programmatic Agreement (PA) for Wolf Creek Dam/Lake Cumberland. The PA will address the adverse affects to significant archaeological sites and identify mitigative measures that will be taken by the Corps of Engineers to address the identified adverse effects. Should you have any questions please feel free to contact Lori Stahlgren of my staff at 502.564.7005, ext 151.

Sincerely,

Donna M. Neary

Donna M. Neary, Executive Director
Kentucky Heritage Council and
State Historic Preservation Officer

LCS:lcs

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 4
ATLANTA FEDERAL CENTER
61 FORSYTH STREET
ATLANTA, GEORGIA 30303-8960

November 20, 2007

Chip Hall
Project Planning Branch
U.S. Army Corps of Engineers, Nashville District
P.O. Box 1070
Nashville, Tennessee 37202-1070

SUBJECT: Draft Environmental Impact Statement for Wolf Creek Dam/Lake Cumberland Project, Emergency Measures in Response to Seepage in Jamestown, Kentucky; CEQ Number 20070425

Dear Mr. Hall:

The U.S. Environmental Protection Agency (EPA) has reviewed the referenced Draft Environmental Impact Statement (EIS) in accordance with its responsibilities under Section 309 of the Clean Air Act and Section 102(2)(C) of the National Environmental Policy Act (NEPA). The Wolf Creek Project, owned and operated by the U.S. Army Corps of Engineers (USACE), is located on the Cumberland River near Jamestown, Kentucky. The Wolf Creek Dam is a combination earthen fill and concrete structure approximately 5,736 feet long and 258 feet high. Lake Cumberland, created by the dam, has a drainage area of 5,789 square miles and a surface area of 63,530 acres.

Since the 1960s, seepage through the dam's foundation has been a concern. Repairs have been implemented at various times including grout injection into the foundation and the installation of a diaphragm wall through about two-thirds of the earthen embankment. These repairs are credited with saving the dam; however, some seepage problems remained. In recent years, the problems have increased and the dam is now classed as being in an active failure mode. To address these problems, the USACE developed specific dam repair and remediation projects in 2006 and 2007. At the time, no significant changes to the normal pool elevations were considered necessary. However, the repairs identified will take a number of years to complete and the risk of potential dam failure will increase during this time. Therefore as a proactive measure, the USACE proposes to evaluate different interim lake elevations to reduce the hydrostatic pressure and potential risk of dam failure. When repairs are complete, the Wolf Creek Project would return to normal operations.

Lake levels at Lake Cumberland have historically been managed in accordance with the Wolf Creek Project Guide Curve. This operations guidance divides the lake into distinct pools (layers) based on three elevations (EL 760, 723, and 673) which form boundaries for project operations throughout the year. The bottom layer of Lake Cumberland is the inactive storage pool (from the bottom of the reservoir up to EL 673). The next zone is the power pool, which is a 50-foot "normal operating zone" between EL 673 and 723. This is the zone in which water is stored for hydropower and other project purposes. The flood control pool extends from EL 723 to EL 760. The normal condition is for this pool to remain empty so that space is available for flood water storage. Overall normal project operations have historically followed a guide curve within a "Power Marketing Band" (PMB), which falls within the power pool and represents the optimal range for power generation. The normal summer pool elevation is EL 723, and the normal winter pool elevation is EL 683. For the purposes of the Draft EIS, this is considered the no action alternative. However in January 2007, due to the risk associated with the dam's instability, the USACE deemed it necessary to take emergency action and lower the target pool elevation at Lake Cumberland to EL 680 to ease the stress on the dam's foundation until repairs can be made. A total of five interim pool elevation alternatives (e.g., temporary operating bands or guide curves) were evaluated in the Draft EIS, ranging from maintaining Lake Cumberland at normal levels to a drawdown to EL 650. No overall preferred alternative was identified.

In general, EPA supports the purpose and need for the action proposed in the Draft EIS. EPA understands that lake levels must be managed as part of dam remediation activities to first and foremost maintain public safety and minimize the risk of dam failure. However, EPA has environmental concerns with some of the alternatives related primarily to water quantity and water quality in the reservoir and project dam releases. EPA offers the following specific comments for your consideration in development of the Final EIS for this project:

Alternatives

EPA understands the dynamic nature of operations at the Wolf Creek Project during this time of dam repairs; however, EPA is unclear of the status of the alternatives described in the Draft EIS, particularly selection of a preferred alternative, based on a recent press release from the USACE. The USACE announced in a press release (October 2007) that a decision-making process has been developed to consider higher future lake levels at Lake Cumberland. The release suggested that the process would be used in early 2008 when the upstream grout curtain is anticipated to be complete. The process would allow for incremental changes in lake elevations depending on the continued satisfactory results of performance indicators and structural improvements to the dam's foundation. The incremental raise being considered would be in the range of five to ten feet. How is this process related to what is described in the Draft EIS? It does not appear that the Draft EIS includes this process, as described in the press release, as an alternative. Alternative 4 appears to be the only alternative that involves the ability to adjust lake levels depending on certain situations.

In the absence of anything specific in the Draft EIS, EPA recommends that the USACE consider an aggressive adaptive management alternative in the Final EIS for managing lake levels during dam repairs, similar to what is described in the USACE press release. Based on information in the Draft EIS and press release, it would appear that conditions at the project are improving and the dam is becoming safer as repairs are completed. A preferred alternative should be selected that includes thorough project monitoring with the ability to allow for higher lake levels (above EL 680) based on certain performance indicators at the project, such as piezometers, wet spots, and settlement on top of the dam.

In addition, there does not appear to be any information in the Draft EIS about the anticipated timeframe for the duration of interim lake levels during dam repair activities associated with the alternatives. EPA recommends that the Final EIS include a discussion of the anticipated length of time that the lake levels would be lowered below normal until repairs are complete.

Water Quality/Water Quantity

It appears that water quality and aquatic resources would sustain moderate to severe adverse impacts under any of the action alternatives. At the lower operating bands, virtually all project purposes except for flood control would be moderately to severely impacted. Water quality, particularly dissolved oxygen (DO) and temperature, would become major concerns, especially in the project tailwaters and downstream. The fisheries both in the lake and in the tailwater would be stressed. Poor water quality together with algal and bacterial blooms would require additional processing by municipal water suppliers. If the USACE selects any of these alternatives, it appears that discharges from Lake Cumberland, downstream of the dam, will not likely meet state water quality standards for DO during mid to late summer. Therefore, EPA recommends immediate implementation of the mitigation measures described in Section 2.5 to ensure that discharges from the project meet state water quality standards. See additional comments on mitigation and monitoring below.

Water quantity is an important consideration for water supply and water quality. It is understood that lowering pool elevations would increasingly benefit flood storage; however, the availability of water quantity downstream of the Wolf Creek Project could be greatly reduced. Wolf Creek normally contributes up to 69% of the Cumberland River flow. From a cumulative impacts standpoint, since similar restrictions are being considered for the Center Hill Project, EPA strongly recommends that the USACE develop interim changes to the operating protocols at other lakes in the Cumberland watershed to provide supplemental flows, as necessary, as described in Section 2.5.3. Perhaps this is also what is proposed as part of Alternative 5. This should be explained in the Final EIS.

Mitigation and Monitoring Measures

A number of potential mitigation measures are described in Section 2.5 for the Wolf Creek Project. For example, Section 2.5.1 references an operating protocol that involves blending turbine and sluice gate discharges to provide continuous minimum flows with high levels of DO. Section 4.3 describes this as an important water management option to provide cold, oxygenated water for the tailwater and to conserve the zone of cold water in the lake used by important fish species. This appears to be an important measure to minimize impacts of the proposed drawdown on downstream water quality. However, it is unclear if this measure (or others listed in Section 2.5) is being proposed as part of this action.

EPA recommends that the Final EIS clearly identify the specific mitigation measures and any monitoring efforts that will be implemented at the Wolf Creek Project associated with the changes in lake elevations from dam remediation efforts. From a water quality standpoint, there is little information in the Draft EIS that describes current water quality monitoring associated with the project. EPA supports an overall monitoring approach following completion of the EIS process that includes rigorous DO and temperature monitoring and a commitment to pursue additional DO enhancement measures based on the results of this monitoring. EPA is interested in water quality monitoring in the project area to determine compliance with state water quality standards, especially during this time of changing project conditions. Monitoring should be utilized to determine the impacts of the changes in lake elevations, associated flow releases, and other project changes on water quality. EPA recommends that the Final EIS include a project operations and flow monitoring plan that identifies water quality monitoring to support such an objective, if this is not already in place.

EPA also recommends that the USACE consider including a "mitigation" measure related to public outreach during this time of interim operations. This commitment could include more detailed, up-to-date monitoring information (reservoir levels, downstream flows, etc.) on a publicly available website to inform the public of current operations, the status of repairs, and any proposed changes to lake levels (immediate or longer-term) that are necessary as a result of dam distress monitoring. This would be a part of the adaptive management approach described above. These measures and a proposed implementation schedule should be included in the Final EIS.

We rate this document EC-1 (Environmental Concerns). Enclosed is a summary of definitions for EPA ratings. We have concerns that the proposed action identifies the potential for impacts to the environment that should be avoided/minimized. We appreciate the opportunity to review the proposed action. Please contact Ben West of my staff at (404) 562-9643 if you have any questions or want to discuss our comments further.

Sincerely,

Heinz J. Mueller, Chief
NEPA Program Office
Office of Policy and Management

Enclosure

cc: Tennessee Department of Environment and Conservation

U.S. ENVIRONMENTAL PROTECTION AGENCY
ENVIRONMENTAL IMPACT STATEMENT (EIS) RATING SYSTEM CRITERIA

EPA has developed a set of criteria for rating Draft EISs. The rating system provides a basis upon which EPA makes recommendations to the lead agency for improving the draft.

RATING THE ENVIRONMENTAL IMPACT OF THE ACTION

- LO (Lack of Objections): The review has not identified any potential environmental impacts requiring substantive changes to the preferred alternative. The review may have disclosed opportunities for application of mitigation measures that could be accomplished with no more than minor changes to the proposed action.

- EC (Environmental Concerns): The review has identified environmental impacts that should be avoided in order to fully protect the environment. Corrective measures may require changes to the preferred alternative or application of mitigation measures that can reduce the environmental impact.

- EO (Environmental Objections): The review has identified significant environmental impacts that should be avoided in order to adequately protect the environment. Corrective measures may require substantial changes to the preferred alternative or consideration of some other project alternative (including the no action alternative or a new alternative). The basis for environmental objections can include situations:

  1. Where an action might violate or be inconsistent with achievement or maintenance of a national environmental standard;
  2. Where the Federal agency violates its own substantive environmental requirements that relate to EPA's areas of jurisdiction or expertise;
  3. Where there is a violation of an EPA policy declaration;
  4. Where there are no applicable standards or where applicable standards will not be violated but there is potential for significant environmental degradation that could be corrected by project modification or other feasible alternatives; or
  5. Where proceeding with the proposed action would set a precedent for future actions that collectively could result in significant environmental impacts.

- EU (Environmentally Unsatisfactory): The review has identified adverse environmental impacts that are of sufficient magnitude that EPA believes the proposed action must not proceed as proposed. The basis for an environmentally unsatisfactory determination consists of identification of environmentally objectionable impacts as defined above and one or more of the following conditions:

  1. The potential violation of or inconsistency with a national environmental standard is substantive and/or will occur on a long-term basis;
  2. There are no applicable standards but the severity, duration, or geographical scope of the impacts associated with the proposed action warrant special attention; or
  3. The potential environmental impacts resulting from the proposed action are of national importance because of the threat to national environmental resources or to environmental policies.

RATING THE ADEQUACY OF THE ENVIRONMENTAL IMPACT STATEMENT (EIS)

- 1 (Adequate): The Draft EIS adequately sets forth the environmental impact(s) of the preferred alternative and those of the alternatives reasonably available to the project or action. No further analysis or data collection is necessary, but the reviewer may suggest the addition of clarifying language or information.

- 2 (Insufficient Information): The Draft EIS does not contain sufficient information to fully assess environmental impacts that should be avoided in order to fully protect the environment, or the reviewer has identified new reasonably available alternatives that are within the spectrum of alternatives analyzed in the Draft EIS, which could reduce the environmental impacts of the proposal. The identified additional information, data, analyses, or discussion should be included in the Final EIS.

- 3 (Inadequate): The Draft EIS does not adequately assess the potentially significant environmental impacts of the proposal, or the reviewer has identified new, reasonably available, alternatives, that are outside of the spectrum of alternatives analyzed in the Draft EIS, which should be analyzed in order to reduce the potentially significant environmental impacts. The identified additional information, data, analyses, or discussions are of such a magnitude that they should have full public review at a draft stage. This rating indicates EPA's belief that the Draft EIS does not meet the purposes of NEPA and/or the Section [illegible] iew, and thus should be formally revised and made available for public comment in a supplemental or revised [illegible].

ENVIRONMENTAL AND PUBLIC PROTECTION CABINET
OFFICE OF THE SECRETARY

Ernie Fletcher
Governor

Capital Plaza Tower
500 Mero Street, 5th Floor
Frankfort, Kentucky 40601
Phone: (502) 564-3350
Fax: (502) 564-3354
www.environment.ky.gov

Teresa J. Hill
Secretary

November 26, 2007

Mr. Chip Hall (CELRN-PM-P)
Department of the Army
Nashville District, Corps of Engineers
P.O. Box 1070
Nashville, TN 37202-1070

RE: Wolf Creek Dam/Lake Cumberland. Emergency Measures in Response to Seepage. Draft Environmental Impact Statement (SERO 2007-29)

Dear Mr. Hall:

The state agencies of the Commonwealth of Kentucky received your October 5, 2007 request for comments on the Draft Environmental Impact Statement (DEIS) for actions at Wolf Creek Dam and Lake Cumberland under the National Environmental Policy Act (NEPA). We appreciate the opportunity to provide comments during the NEPA process.

As the state agency responsible for coordinating the review of documents prepared under NEPA, the Environmental and Public Protection Cabinet solicited comments from the other state agencies involved in the Wolf Creek Dam and Lake Cumberland activities and consolidated them as one response from the Commonwealth of Kentucky state agencies.

The attached comments are provided on the Draft Environmental Impact Statement and the proposed alternatives. In light of the emergency nature of the actions at Wolf Creek Dam, we understand the necessity of initiating action prior to completing the NEPA process. We look forward to working to minimize impacts of these actions and assist you in implementing a plan that also minimizes the risk to the integrity of the dam. Larry Taylor (502-564-2150) in the Commissioner's Office of the Department for Environmental Protection is available if you have further questions.

Sincerely,

Teresa Hill
Secretary

COMMONWEALTH OF KENTUCKY COMMENTS
WOLF CREEK DAM/LAKE CUMBERLAND
EMERGENCY MEASURES IN RESPONSE TO SEEPAGE
DRAFT ENVIRONMENTAL IMPACT STATEMENT

Governor Ernie Fletcher established a work group in January 2007 to develop a plan to reduce the potential impacts of actions at Lake Cumberland and Wolf Creek Dam and provide a coordinated response to needs in the area. The work group is comprised of agencies with expertise in areas affected by the actions at Wolf Creek Dam. The primary concerns are the safety of the citizens, the integrity of the Wolf Creek Dam, the protection of the natural resources of Lake Cumberland, and the economic impact on local businesses. The desire is to reduce the risk of dam breech while minimizing adverse impacts.

By letter dated October 5, 2007 the Army Corps of Engineers solicited comments on the Draft Environmental Impact Statement prepared as required by the National Environmental Policy Act. This document is the collective response from Commonwealth of Kentucky state agencies.

Kentucky Department of Fish and Wildlife Resources

The Department of Fish and Wildlife Resources has the following comments and recommendations on the Draft Environmental Impact Statement.

Recreation:

The DEIS acknowledges that the project will impact boat ramps and may impact fisheries. The preferred alternative acknowledges loss of recreation by at least 50% and the possibility of impacts to fisheries in the tailwaters and lake. The economic contribution of fishing related recreation is significant. Expected losses to recreation and fishing-related recreation are significant. The DEIS estimates losses to be $75 million annually to local communities. Boat ramps are being extended to maintain access. Recreational losses associated with fisheries impacts are not being offset as part of the project. The tailwater fishery alone has an estimated $7.1 million annual economic impact. Additional minimization measures and mitigation should be provided to reduce impacts.

Water Quality and Aquatic Resources:

We believe there will be a net loss to the fisheries during and for a period of time following the project based on our estimates and information in the DEIS. The DEIS acknowledges that the project could, and in certain cases is likely to, negatively affect the fisheries in the lake and tailwaters. The replacement value of walleye and striped bass in the lake is $64.5 million. Recovery time for the lake fishery to pre-project levels would take 10-15 years after the project is completed.

The DEIS uses spatial boundary downstream to Barkley Dam as the area of potential effect which encompasses a wide range of uses and demands for the water. The first 75 miles of river below the dam in Kentucky is unique in that it provides a premier coldwater fishery. The significance of this resource to Kentucky and to the Cumberland River system warrants additional minimization and mitigation measures than the DEIS presents.

The DEIS indicates the sluice gate has been used to improve dissolved oxygen levels in the tailwaters in pre-project conditions. Fish kills in the lake and depressed dissolved oxygen levels have occurred in pre-project conditions. The DEIS acknowledges that sluicing can be effective only up to a point. The sluice gate does not address maintenance of minimum flows in the tailwaters. The use of sluice gates as a minimization measure offers nothing different from existing project conditions. For these reasons, we believe that sluicing alone is insufficient to offset the short term impacts of the project or the long term needs of the tailwater fishery.

The fishery in the tailwaters is dependent upon a sustainable, healthy trout population which is maintained only through adequate flows of cold, oxygenated water. Temperatures in the lower reaches of the tailwaters, below Burkesville recorded by KDFWR biologists over the last year have been too high to sustain the trout fishery there. KDFWR fisheries biologists have noted that many trout captured in the tailwaters during sampling this past year have been emaciated ,indicating they are stressed. We believe the trout fishery in the tailwaters will be in jeopardy if current operation of the reservoir continues or if adequate temperature, oxygen and flow cannot be achieved with the project.

The DEIS indicates that the pool of Laurel River Lake upstream of Lake Cumberland, could be held higher to benefit recreation, water supply and water quality. The potential impacts of operational changes at Laurel River Lake or the specific benefits to Lake Cumberland have not been fully evaluated. The benefits and effects of this treatment for the Lake Cumberland project and Laurel River Lake are unclear.

The DEIS indicates that there could be a long-term benefit to the lake's fishery with the re-vegetation of the exposed shoreline. We agree that there would be some level of benefit to the fishery through re-vegetation but those benefits would be short-term and not long-term as discussed in the DEIS. Vegetation would decay and be eliminated over time as the lake returns to pre-project conditions. Re-vegetation of the shoreline does not adequately minimize or compensate for the losses to the fishery incurred during the project and offers some but limited post-project benefits. Additional measures should be taken to mitigate significant temporal losses to the fishery and to minimize the recovery time.

Fish Hatchery Impacts:
As stated in previous comment letters, the Wolf Creek National Fish Hatchery (WCHFH) is critical to KDFWR's statewide trout program. The hatchery provides 800,000 trout for stocking statewide. The U.S. Fish and Wildlife Service estimated that rainbow trout production alone at WCHFH created 401,811 angler days, with a combined economic impact of $31,216,500 in 2004. Operations at the hatchery are dependent on sufficient supply of coldwater with adequate dissolved oxygen levels.

Automatic auxiliary pumps and a manifold system were installed to provide adequate water to the hatchery during the project. The automatic pump system lacks a back-up mechanism to guard against failure. A night time failure would result in a fish kill at the hatchery. The manifold intake is at 618 feet which does not provide adequate coldwater supply at current lake levels. The manifold currently pulls from various depths in the lake mixing cold and warm water. This mixing does not provide sufficiently high dissolved oxygen levels for the hatchery operations.

Recommended modifications to these minimization measures are discussed below.

KDFWR Recommendations:

On Table 1, page 16, Comparison of Impacts, the column heading Alternative 5 should be Alternative 4 and column heading Alternative 6 should be Alternative 5.

1. Pool Levels:

We recommend a minimum pool level of 695 feet to be available from spring through early fall. Pools levels of 695 or above allow the best option for minimizing effects to the fisheries, recreation, water quality, recreationally-related economic impacts. This translates into a 28% increase in reserve volume from 680 feet adding to the coldwater budget in the lake. We recommend that this pool be achieved early in spring to allow the development of the coldwater reserve and that releases be made gradually through October. Gradual releases benefit the fishery in the lake and allow for coldwater maintenance in tailwaters.

The recommendation for holding the pool at 695 feet would be achievable in Alternative 4. The DEIS indicates that this option provides for other concerns such as safety, system reservoir operations, and water supply for fire fighting to upstream and downstream uses.

2. Mitigation of Fisheries and Water Quality Impacts:

The DEIS indicates that re-vegetation of the shoreline could help in the recovery of the lake fishery after the project is completed. The shoreline is already growing vegetation through natural succession. We do not recommend supplemental plantings.

We recommend that the project include the creation of permanent habitat improvement to mitigate the loss in the fishery during the project and to enhance the recovery after the project is completed. Specifically, we recommend the creation of rock reefs, jetties, and rock structures on the main lake along the shoreline. The habitat features should be created at elevations where they would provide habitat after the project is completed and the pool returns to the original levels. These features would provide habitat throughout the year, but would directly minimize project effects by enhancing spawning and nursery habitat, expediting recovery of the fishery.

We recommend that the project include additional structural and operational measures to increase dissolved oxygen levels and minimum flows in tailwaters to minimize project impacts. Specifically, we recommend that an orifice gate be installed to allow minimum flow of 500 cfs through the sluice gates. Additional baffles or other structures that increase dissolved oxygen levels should be added to the project. Higher seasonal pool levels recommended previously would help to provide adequate minimum flow of cold water during the project.

We recommend the development of a reservoir model and the ability to monitor water quality in real time. Specifically, we request a reservoir model that shows whether spring sluicing will preserve the coldwater reserve. The preservation of the coldwater reserve would be protective of water quality and aquatic resources in the lake and tailwaters and provide managers with more certainty in decision-making. Real time water quality monitoring will provide easily accessible data to resource agencies and stakeholders.

Temperature data and observations suggest that project impacts to the trout fishery in the tailwaters may be occurring already. We recognize that few options exist that would offset these impacts. We recommend supplemental commercial stocking of trout and adopting the hatchery recommendations below as means to minimize the project effects.

3. <u>Hatchery Impacts:</u>
Three outstanding issues need to be addressed to minimize project effects to the hatchery.

1. Two emergency auxiliary pumps have been installed to provide water supply to the hatchery as part of the project. Only one pump is used at a time. There is no automatic switching system for these emergency pumps. A failure of the operating pump during night time when managers are off duty will result in a fish kill at the hatchery. We recommend that a back up system be installed to guard against this possibility.

2. A manifold system was installed last year to meet hatchery water needs. The current intake at 618 feet is too shallow at current lake levels to access coldwater. We recommend lowering the intake to an elevation that will provide the necessary coldwater for hatchery operations.

3. An aeration system needs to be installed to add adequate oxygen to the hatchery intake water. An additional aeration tower could increase trout production at the hatchery by up to 10%. This increase would help minimize project impacts.

Environmental and Public Protection Cabinet (EPPC), Department for Environmental Protection, Division for Air Quality
Actions must be in compliance with requirements related to fugitive emissions and open burning as described in 401 KAR 63:010 and 401 KAR 63:005 and compliant with any applicable local government regulations. The Division for Air Quality has developed a Fugitive Emissions Fact Sheet and an Open Burning Fact Sheet at the following locations.
http://www.air.ky.gov/homepage_repository/e-Clearinghouse.htm
http://www.air.ky.gov/homepage_repository/e-Clearinghouse.htm

EPPC, Department for Environmental Protection, Division of Water
Water tables adjacent to the lake were lowered when the lake level was lowered in early 2007. This impacted several private water wells in the area, either by significantly lowering their water levels, or by completely dewatering these wells. These impacts will continue if the lake level is maintained at 680 ft., and will become more severe if the lake level is lowered further.

The Groundwater Branch, Kentucky Division of Water, has reviewed water well data for this area and estimates that as many as 600 private wells used for various purposes near the lake could be affected as water tables decrease coincident with lake level decreases.

In early 2007, the Groundwater Branch inspected several wells affected by lowering lake levels and advised owners of their options, which include: 1) hooking onto a public water system (PWS), 2) hauling water from other sources, including from neighbors on a PWS or functioning wells, or from local springs, or 3) if feasible, lowering their pumps or deepening their wells—however, these options are risky, especially given the possibility that the lake level may be lowered further or that underlying formations may not yield the necessary quantity or quality of groundwater. If springs are considered, the Groundwater Branch should be notified in order to survey and sample the spring and to advise potential users on water quality and treatment issues.

State technical assistance has been made available to extend PWS service in several affected areas and should continue as needed. If, however, this option is not available, residents should be advised regarding other options. The Kentucky Division of Water can assist this effort.

In addition, there is a minor risk of sinkhole collapse due to lowering lake levels, both within the lake bed itself and in adjacent areas. However, in the lake bed where no development has occurred, this should not be a significant problem. In adjacent areas, any sinkhole collapses that may occur, could be locally significant, and could damage building foundations, roads, etc.

The EIS should note these impacts, as well as existing or planned efforts to mitigate them.

Kentucky Transportation Cabinet

The Transportation Cabinet is currently performing an archaeological and historic baseline survey for the Cumberland River area from the dam to Creelsboro. That information will be available to the Corps when it is completed and will not have to be duplicated by the Corps. For further information contact Mike Hancock (502-564-3730) in Frankfort or Cathi Blair (606-677-4017) in the KYTC District 8 office in Somerset.

Commerce Cabinet, Kentucky Heritage Council, State Historic Preservation Office

The most recent archaeological assessment field survey conducted after the drawdown has revealed that numerous recorded and previously unrecorded archaeological sites, both historic and prehistoric are present within the project area. Eleven of the 72 archaeological sites examined during the course of this project were determined to be potentially eligible for listing in the National Register of Historic Places. In addition to these sites, maintaining Lake Cumberland at its current lower pool height of 680 feet has the potential to impact several hundred other archaeological sites that have yet to be documented by professional archaeologists. All of these historic properties will be adversely affected by continued exposure to erosion and extensive collecting and looting. The latter is a violation of the Archaeological Resources Protection Act.

With this in mind, we recommend that the immense potential loss of significant cultural information be included within the Cumulative Impacts of the Environmental Statement. Once these resources disappear, through erosion or looting, they are gone forever and part of our history is irrevocably lost.

We look forward to working with the Corps of Engineers, the Advisory Council on Historic

Preservation, relevant Native American tribes, and other consulting parties to develop and implement a Programmatic Agreement (PA) for Wolf Creek Dam/Lake Cumberland. The PA will address the adverse affects to significant archaeological sites and identify mitigative measures that will be taken by the Corps of Engineers to address the identified adverse effects. Contact Lori Stahlgren of the State Historic Preservation Office at 502-564-7005, ext 151 for further information.

DEPARTMENT OF THE ARMY
NASHVILLE DISTRICT, CORPS OF ENGINEERS
P. O. BOX 1070
NASHVILLE, TENNESSEE 37202-1070

DEC 13 2007

IN REPLY REFER TO
Project Planning Branch

Ms. Teresa Hill, Secretary
Environmental and Public Protection Cabinet
Office of the Secretary
Capitol Plaza Tower
500 Mero Street, 5th Floor
Frankfort, Kentucky 40601

Dear Ms. Hill:

This is in response to your letter of November 26, 2007, regarding agency comments on the *Wolf Creek Dam/Lake Cumberland Emergency Measures in response to Seepage Draft Environmental Impact Statement*. As you are aware, Wolf Creek Dam's foundation has shown signs of serious seepage problems. To minimize the risk to downstream populations, an emergency was declared and Lake Cumberland was drawn down to elevation 680. The Corps is striving to maintain this elevation until repairs can be effected and the lake is returned to its normal operating regime.

The Environmental Impact Statement (EIS) mentioned above described a range of alternatives to this action, the anticipated consequences of each action, and the possible minimization and mitigation of adverse effects. Several of your departments have provided comments and recommendations to improve our course of action. By means of this letter I want to assure you that all of your comments have been considered and where possible your recommendations are being incorporated into the Final EIS. Some of the specific issues being addressed are as follows:

The Kentucky Department of Fish and Wildlife Resources (KDFWR) noted significant losses to recreation. Our own visitation figures indicate a decrease of about 10% over previous fiscal years or 16% over the calendar year and the marina operators have reported 30 to 50% reductions in revenues. To minimize the impact to recreators we have extended many boat ramps and issued permits to other parties to extend their ramps as well. The marina's leases were renegotiated and their annual rent was reduced to $1. One marina has been relocated and a second marina's request for relocation is being processed.

KDFWR has noted that the first 75 miles below Wolf Creek Dam provides a unique coldwater fishery and desires additional minimization and mitigation measures. The Corps has worked closely with the KDFWR and the U.S. Fish and Wildlife Service (FWS) to find ways to do just that. Minimum releases have been maintained in the tailwater. Studies have been conducted to determine the optimal minimum flows below the dam and the Corps is fabricating and installing orifice gates over the sluice gate entrances to better regulate minimum flow releases. These orifice gates will provide a mechanism to provide a continuous minimum flow of approximately 500 cfs. These new gates offset short-term impacts and provide support of the coldwater fishery downstream of the dam by supplying a constant supply of well oxygenated water that meets or exceeds the state water quality requirements.

KDFWR was concerned about the high temperatures in the lake and the tailwater this last summer. The Corps was also concerned; however, due to the drought across the region there was no excess water to release to mitigate the temperature increases. In spite of the drought the Corps maintained minimum releases to ensure steady flows. The large fish kills that were anticipated both in the lake and in the tailwater did not come to pass. In fact, the KDFWR was recently quoted as stating that fishing in the tailwater doesn't get any better. KDFWR was recently quoted in news articles; "The quality of the fishery is probably as good as it has ever been." KDFWR has requested additional mitigation and compensation for losses incurred by the fishery, however, to date, no mitigation, in addition to that which has been completed, or is currently proposed to lessen impacts to the tailwater fishery, is planned at this point.

KDFWR stated that potential impacts of operational changes at Laurel River Lake have not been fully evaluated. Although some water was released from Laurel River Lake to help maintain pool levels in Lake Cumberland during the drought. The vast difference in size (volume) between these two lakes precludes Laurel River Lake from providing significant long-term benefits to managing lake levels at Lake Cumberland. These releases were within the approved operational curves established for the lake and require no further evaluation.

Specific recommendations by KDFWR include a minimum pool elevation of 695 from the spring through the fall to establish a coldwater reserve and that releases be made gradually through October. Although the Corps would like to comply with this recommendation, the safety of the downstream populations must take precedence when determining an appropriate pool elevation. The Corps has developed a decision making process to decide at which pool level Lake Cumberland should be held. This decision making process will be used at certain points in time for the duration of the construction project regardless of the alternative chosen. Examples of times at which this process would take place are: completion of the upstream grout line (estimated early 2008), completion of the downstream grout line (estimated September 2008), completion of the cut-off wall in Critical Area 1 (estimated September 2009), etc. The decision making process will be based on the completion of these structural measures and validated by performance indicators and continued overall stability and improvement in Wolf Creek Dam. The performance indicators are: the continued stable, downward trend of Piezometer readings, continued reduction in the size of wet spots, no anomalies in monitored dam or embankment settlement, and no anomalies based on visual inspections. This information will be used by an in-house team and a Corps advisory panel to make recommendations on incremental pool level changes of no more than 10 feet at a time.

KDFWR has recommended the construction of rock reefs, jetties, and rock structures on the main lake along the shoreline to provide fish habitat. We believe this is a good idea and funding for this has been requested. Language proposing this action as mitigation has been added to the Final EIS. If funding is approved and received we would like to collaborate with KDFWR to determine the best designs and locations. If KDFWR has the resources and would like to construct some of these structures we would be glad to assist them in obtaining the necessary permits.

KDFWR requested a reservoir model of the coldwater reserves and the ability to monitor water quality in real time. The Corps has an existing water quality model for Lake Cumberland. The model has been updated to the latest version and will be available for use in 2008. The coldwater budget is determined by the amount and timing of precipitation and air temperatures. Cold winters are necessary to cool the lake waters. The cold snap in early 2007 cooled the lake waters by about 4°C. This may not happen every year. The Corps currently has near real time water monitoring and data. In the past the Corps conducted four trips per year to collect water quality data. Two of these trips conducted profiles and full chemical analyses and the other two checked profiles only. We also conducted biweekly grab sampling of in situ parameters during the warm season, i.e., May through November and monthly grab samples from December through April. Since declaring the emergency the Corps has increased its monitoring program. We now conduct three full sampling trips and two additional for profiles only. We have also added biweekly collections of profiles in the forebay and upstream stations to better define water quality conditions from April through December and monthly collections from January through March. We also collect data in the tailwater and other downstream locations as needed, specifically at Cumberland River Miles 459, 456, and 437 and have installed temperature probes at several additional sites. Monitoring data is immediately fed back into decision making processes and is sent to affected parties (mostly agencies).

The KDFWR stated concerns for the Wolf Creek National Fish Hatchery. The Corps has been and will continue to work closely with the FWS to minimize impacts to the hatchery. Although two auxiliary pumps were installed with the intention of maintaining one in operation and one as a backup, FWS is currently running both of the pumps full time during the day and one pump at night. An alarm system has been installed to alert both the FWS and the Corps in the event of a pump failure. The dam's control room is staffed at all times. Should there be a pump failure the second pump would be started manually. The Corps has also been consulting with the FWS regarding the multi-level intakes structure. Prior to the lowering of Lake Cumberland the structure was upgraded by the Corps as part of a project funded by FWS. In January 2008, divers are scheduled to initiate work to repair a leak in the structure and to replace a malfunctioning valves inside the dam. No decision has been made to determine if the structure should be lowered.

The Department for Environmental Protection, Division of Water noted that several private water wells in the vicinity of the lake have gone dry and believes as many as 600 wells could be affected by the reduced lake levels. In addition, it noted a minor risk of sinkhole collapse due to the lowered lake levels. Lake Cumberland typically fluctuates 30 to 45 feet annually and lake levels below elevation 680 are not unknown. No dry wells were reported during those events. We also note that this year experienced an extreme drought and that this could be the cause of the dry wells. Wells on private property are not covered under the Corps' authorities. The Corps is not aware of any direct ties to sinkhole collapses due to lake operations, although with the karst geology the possibility of sinkhole collapses is always present.

The State Historic Preservation Officer mentioned that numerous recorded and unrecorded historic and prehistoric sites are present within the project area. Eleven of the 72 sites examined during the post-drawdown survey were determined eligible for listing in the National Register of Historic Places, and several hundred sites have yet to be properly documented. All exposed sites will be adversely affected by continued exposure and looting. The Corps concurs that this potential loss will be included in the Cumulative Impacts section of the EIS and that a Programmatic Agreement should be developed.

We appreciate your comments and recommendations and look forward to working with your various departments to resolve these issues. If you have any further comments or recommendations please feel free to contact Mr. Chip Hall at the address above or by telephoning him at 615-736-7666. A copy of this letter was sent to Mr. Larry Taylor, Kentucky Department of Environmental Protection.

Sincerely,

Patricia L. Coffey

Patricia L. Coffey
Chief, Project Planning Branch

From: Gregory_Hogue@ios.doi.gov
To: Modification, Lake LRN;
Subject: DEIS Wolf Creek Dam/Lake Cumberland
Date: Tuesday, November 27, 2007 5:46:23 AM

ER 07/855
9043.1

Mr. Chip Hall
Project Planning Branch
U.S. Army Corps of Engineers

RE: Wolf Creek Dam/Lake Cumberland, Kentucky, Draft Environmental Impact Statement

Dear Mr. Hall:

The Department of the Interior has reviewed the referenced document to address emergency measures in response to seepage and have no comments to provide at this time. You can contact me at the address and/or phone numbers below.

Gregory Hogue
Regional Environmental Officer
Department of the Interior
Ofc of Environmental Policy & Compliance
75 Spring St., SW, Rm 1144
Atlanta, GA 30303
404-909-0537 (24HR)
404-331-4524 (ofc)
404-331-1736 (FAX)

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Kentucky Ecological Services Field Office
330 West Broadway, Suite 265
Frankfort, Kentucky 40601
(502) 695-0468

December 7, 2007

Ms. Patty Coffey
U.S. Army Corps of Engineers
Nashville District, Planning Branch
P.O. Box 1070
Nashville, Tennessee 37202-1070

SUBJECT: Comments on the Wolf Creek Dam/Lake Cumberland, Emergency Measures in Response to Seepage, Draft Environmental Impact Statement (FWS #2008-B-0075, ER 07/0855)

Dear Ms. Coffey:

The Kentucky Field Office, in coordination with the Cookeville Field Office and Wolf Creek National Fish Hatchery, has reviewed the U.S. Army Corps of Engineers Wolf Creek Dam/Lake Cumberland, Emergency Measures in Response to Seepage, Draft Environmental Impact Statement and provides the following comments.

Introduction and Background

The Nashville District Corps of Engineers has prepared the DEIS to evaluate its proposed and on-going measures to address seepage in Wolf Creek dam. Wolf Creek dam was built on karst geology using accepted engineering practices at the time; however, since the 1960's, seepage through the dam's foundation has become a significant public safety concern. Repairs to the dam have occurred at various times, including grout injection into the foundation and the installation of a diaphragm wall through about two thirds of the earthen embankment. Nonetheless, the seepage problems have increased over the past three decades, and the dam is now classified as being in an active failure mode.

Due to public safety risks created by the dam's instability, the Corps, on January 19, 2007, determined that it was necessary to take emergency action and lower the pool elevation of Lake Cumberland to 680 feet. Lowering of the pool to this level is believed sufficient to ease the stress on the dam's foundation until repairs can be made. As a result, the Corps believed that the need for action was urgent and compelling and that there was not time to follow normal NEPA procedures. The Corps, therefore, invoked its authority under 33 CFR 230.8 "Emergency Actions" and declared an emergency, made necessary decisions, and took necessary actions to address the public safety risks. The Corps consulted the Presidents's Council on Environmental Quality (CEQ) regarding alternative arrangements under NEPA pursuant to 40 CFR 1506.11.

The DEIS identifies seven alternatives: 1) No Action; 2) Maintain Lake Cumberland pool height at 680 feet; 3) Maintain Lake Cumberland pool height at 650 feet; 4) Maintain Lake Cumberland with a partial fill guide curve between 685 and 700 feet; 5) Manage the Cumberland River system in accordance with an Interim Operating Plan; 6) Maintain Lake Cumberland pool height at 610 feet; and 7) Construct a new roller-compacted concrete dam downstream of the existing dam. Due to the emergency nature of the dam's integrity, Alternatives 2 and 5 have already been chosen by the Corps for the current emergency period and are being carried out. Further, the DEIS only evaluates Alternatives 1-5; Alternatives 6 and 7 were eliminated for various reasons. The Corps' preferred environmental Alternative would be to continue to operate Wolf Creek Dam using the existing guide curve (i.e., no action); however, the consequences of a dam failure outweigh the anticipated negative impacts to the environment. Therefore, the Corps' recommended plan for future interim operation during the time of seepage repairs is to continue to operate the Cumberland Reservoir system in accordance to the Interim Operating Plan and to target a pool elevation of 680 feet at Lake Cumberland unless and until the Corps determines that a different pool elevation level is more appropriate.

General Comments

Many of our comments on the *Draft Environmental Impact Statement, Wolf Creek Dam/Lake Cumberland, Emergency Measures in Response to Seepage* (DEIS) are general in nature, because the DEIS is fairly general in nature and lacks sufficient detail on many of the issues that are important to the Fish and Wildlife Service. The comments in this and the subsequent section identify those areas where more detail or clarification is needed to address the Fish and Wildlife Service's issues. At this point, we do not believe sufficient information and analysis has been generated for the Service to generate a draft Fish and Wildlife Coordination Act report on the proposed project.

The Service supports the Corps' efforts to protect public safety and agrees with the Corps' assessment of the problem and the actions taken to this point. Based on the Corps' assessment in Alternative 2, the 680-foot pool height is the lowest point to which Lake Cumberland could be lowered where additional risks to human health and safety are not also created (i.e., risking the operation of municipal water intakes in Lake Cumberland). Therefore, it seems advisable, as explained in Alternative 5, for the Corps to manage the Cumberland River according to the Interim Operating Plan that takes into account the other ten water resources projects in the Cumberland basin. This is needed because Lake Cumberland is only expected to provide about 8% to 12% of the flow of the Cumberland River during the summer months, where, normally, Lake Cumberland would provide about 69% of the flow of the river. Alternative 5 allows some flexibility in operating the system, which would reduce adverse environmental impacts regardless of lake level target or guide curve.

As the lead Federal agency, the Corps has the responsibility to minimize negative impacts to fish and wildlife resources resulting from the proposed action. The Corps should make every effort to avoid, minimize, and/or compensate for all of the impacts that occur to federal trust resources as a result of this project. We also believe the Corps has the responsibility to improve riverine conditions and resources where possible. As a result, the Service believes the Corps should consider this an opportunity to provide leadership that would benefit fish and wildlife resources in this highly impacted watershed.

Specific comments
Federally-listed Species
Wolf Creek Dam and Lake Cumberland and its embayments lie within Russell, Clinton, Wayne, McCreary, Laurel, Whitley, and Pulaski counties in Kentucky. A total of 25 federally listed and federal candidate species are known from these counties or have the potential to occur in these counties. These species are shown in Table 1 of a letter dated February 12, 2007 from the Service's Kentucky Field Office to Mr. Chip Hall of the Corps. In this letter, the Service also listed several streams containing the federally listed threatened blackside dace (*Phoxinus cumberlandensis)* that are tributaries of the Cumberland River upstream of Wolf Creek Dam. They include Big Lick Branch and one of its tributaries in Pulaski County; Ned Branch (a Rockcastle River tributary) in Laurel County; and Beaver Creek, Fish Trap Branch, and Mill Creek in McCreary County. In addition, Critical Habitat has been designated in several of these counties for three federally listed mussel species. These critical habitat areas are located in watersheds that are also tributaries to the Cumberland River upstream of Wolf Creek Dam. These mussels and their designated Critical Habitat are listed below:

- Cumberland elktoe – Big South Fork, Marsh Creek, and Rock Creek – McCreary County; Sinking Creek, Laurel County; Laurel Fork, Whitley County (69 FR 53136-53180, August 2004)
- Cumberlandian combshell – Big South Fork, McCreary County; Buck Creek, Pulaski County (69 FR 53136-53180, August 2004)
- Oyster mussel – Big South Fork, McCreary County; Buck Creek, Pulaski County (60 FR 53136-53180, August 2004)

The Service is concerned about effects that lowered lake levels will have on federally listed species especially bats, fish, and mussels. This DEIS does not adequately address potential impacts to these species in those habitats that may become available for these species due to the lowering of lake levels (e.g., caves, stream reaches, etc.). Lowered lake levels may cause destabilization of stream channels (i.e., head-cuts that could migrate upstream) that could potentially impact blackside dace habitat in these streams, which would be considered an indirect, adverse effect to this species. Similar impacts could also occur in the designated critical habitat areas described above. The Corps should determine if the proposed project will result in the adverse modification of these critical habitat areas and make appropriate determinations for each critical habitat area.

We also recommend that the Corps carefully monitor habitat conditions in the upper portions of Lake Cumberland that will be de-watered. In particular, we are interested in determining if suitable aquatic and/or terrestrial (e.g., caves) habitat conditions for federally listed species will be temporarily restored to these areas. We recommend the Corps determine the extent (i.e., number of caves, stream miles, etc.) of habitat that will potentially become available to federally listed species as a result of the proposed action. If listed species colonize such areas, additional adverse effects may occur when the Corps returns Lake Cumberland to its normal pool. The Corps should pay particular attention to restored stream reaches and to any cave openings that may be uncovered. Surveys of these habitats will likely be necessary prior to re-filling Lake Cumberland to determine if federally listed fish, mussels, and bats have colonized the restored habitats. Depending on how water levels are manipulated during repairs to the dam, de-watering and inundation of habitat could occur repeatedly.

The Corps made a preliminary No Effect determination for all species except the following mussels for which a May Affect determination was made: fanshell (*Cyprogenia stegaria*), dromedary pearlymussel (*Dromus dromas*), Cumberland combshell (*Epioblasma brevidens*), purple cat's paw (*E. obliquata obliquata*), pink mucket (*Lampsilis abrupta*), ring pink (*Obovaria retusa*), orange-foot pimpleback (*Plethobasus cooperianus*), and rough pigtoe (*Pleurobema plenum*). Based on the information provided in the DEIS, the Service does not have a clear understanding of the Corps' May Affect determinations. We recommend the Corps state the determination as either a "May Affect, Not Likely to Adversely Affect" or as a "May Affect, Likely to Adversely Affect". We recommend the Corps re-evaluate the determinations for these species with this terminology in mind. Further, we recommend that the Corps re-evaluate its No Effect determinations after considering the concerns raised in the previous two paragraphs.

Regarding federally listed freshwater mussels, it is possible that the purple cat's paw no longer exists in the Cumberland River and that the fanshell and orange-foot pimpleback may exist, but most likely in the lower Cumberland River downstream of Barkley Dam. Nonetheless, the Service believes that at least five mussel species (dromedary pearlymussel, pink mucket, rough pigtoe, Cumberland combshell, and ring pink) could be adversely affected by the proposed action. These five species occur between Cumberland River Miles 264 and 308. Potential impacts of both the completed drawdown and future operation and repair activities upon the Cumberland River center around water quality and quantity issues directly related to tailwater discharges. Deviations from normal regulated flow patterns and typical temperature and dissolved oxygen regimes could adversely impact aquatic resources, especially given the fact that the Corps will have decreased ability to regulate the quantity and quality of water available for tailwater discharges. Discussions of some of the adverse effects that may occur to mussels are listed below:

1. The receiving waters of Wolf Creek Dam's discharges are predominately other impounded areas within additional downstream reservoirs. For this reason, rare aquatic species (e.g., federally listed mussels) occur in relatively few locations. Most remnant mussel populations are confined to areas that continue to experience significant flow as the result of tailwater releases. As a consequence of impoundment and consistent low water temperatures, most of these specimens are not expected to reproduce, and older individuals that were present before the impoundments typically dominate the populations. Consideration has been given in recent years to removal of these specimens for use in propagation efforts and to prevent the loss of this genetic pool. In this regard, their potential value to the survival of their respective species remains significant. For example, the big river form of the dromedary mussel is not known to occur anywhere except for the Cumberland River tailwater of Cordell Hull Dam.

2. We believe that the draw-down of Lake Cumberland, along with the concurrent draw-down of Center Hill Lake, would likely cause the water temperature of the Cumberland River to increase. This increase of water temperature for an extended period of time (7+ years) is expected to improve reproductive conditions for existing listed mussel species.

If reproduction occurs, the likelihood of adversely affecting the offspring would be very high once the dam repairs are completed and the low temperature water is once again released. This type of on-going take (e.g., interference with normal reproductive patterns) is a significant issue that should be evaluated by the Corps.

In order to minimize the potential and/or specific adverse effects identified in the section above, we recommend that the Corps consider adopting and/or undertaking the following actions:

1. The Corps should assess the mussel populations below Cordell Hull and Cheatham Dams and salvage listed mussels from those areas. To accomplish this, the Corps could provide funding to the Tennessee Wildlife Resources Agency (TWRA) and/or Service to salvage, to the extent possible, the existing federally listed mussel species at these sites;
2. The Corps should undertake efforts to improve populations of listed freshwater mussels. To accomplish this, the Corps could provide funding to support TWRA's and the Kentucky Department of Natural Resources' (KDFWR) mussel propagation efforts for federally listed species native to the Cumberland River basin;
3. The Corps should undertake efforts to improve populations of listed and at-risk fish species. To accomplish this, the Corps could provide funding to the Service, TWRA, and KDFWR for fish propagation purposes for federally listed and other at-risk species native to the Cumberland River basin;
4. The Corps should undertake efforts to improve and/or restore habitat for federally listed species that has been or will be altered by the proposed action. To accomplish this, the Corps, along with the Service and state partners, could identify opportunities for habitat restoration and enhancement that the Corps would then fund;
5. In the DEIS, the Corps provides several additional conservation measures (see section 5.0 Potential Conservation Measures) including: 1) installation of an orifice gate over a sluice gate, 2) blending turbine and sluice gate discharges, 3) supplemental flows from other tributary lakes, and 4) spilling water through the gates rather that generating. The Service agrees with the Corps that these measures may be appropriate to benefit flows and dissolved oxygen (DO) levels.

We would appreciate the opportunity to discuss the applicability of these measures with the Corps at some point in the near future.

In the DEIS under 4.0 Individual Activity/Species Impacts, we provide the following comments under individual species accounts:

1. Under the Cumberland combshell 4.7.5.2 Effects – In this paragraph, the Cumberland combshell is referred to as the dromedary pearlymussel and also the fanshell mussel.
2. Under the Tan Riffleshell 4.7.7.1 Species Account Summary – The third paragraph should mention that the tan riffleshell population in the Big South Fork Cumberland River is also considered to be recruiting.
3. Under the Catspaw 4.7.8.1 Species Account Summary – This mussel is also currently extant in Killbuck Creek in Ohio.
4. Under Pink Mucket 4.7.10 – In the second paragraph, the Kanawha River is misspelled.

5. Under Ring Pink 4.7.12 – In the second paragraph, the record of the ring pink from the Kanawha River in West Virginia is not a good record; the species was mis-identified. Also in the same paragraph, the citation, Parmalee and Bogan (1998) seems to indicate that commercial fishermen recorded this species in the 1990's. In the book, The Freshwater Mussels of Tennessee, by Parmalee and Bogan, and published in 1998, this record was from the early 1980's.

Under the Effects heading for many of the species accounts, the DEIS indicates that stressors would include lowered DO and increased temperatures, but would also include less dilution of pollutants being discharged into the river. Similarly, under the heading Cumulative Effects, the DEIS indicates significant changes to these stressors. It would be helpful in assessing potential impacts to species, especially the aquatic species, if more information and detail was provided in the DEIS regarding the anticipated DO and temperature changes. As mentioned previously, an increase in temperature would, if sustained for a long period of time, actually benefit some of mussel species in the Cumberland River.

Wolf Creek National Fish Hatchery

Potential adverse impacts may also occur to common aquatic resources adapted to cold tailwaters or existing warmwater impoundments. Many of these species, particularly fish species, are of high recreational importance. However, impacts to these species would likely be temporary, and populations will ultimately recover to pre-project status.

However, the Service operates Wolf Creek National Fish Hatchery (NFH), which is located immediately downstream of Wolf Creek Dam. Wolf Creek NFH began in 1975 and produces all the rainbow and brown trout stocked in Kentucky for recreational fishing. Over 100 waters in Kentucky are stocked with fish from the hatchery. Fingerling trout are also supplied on an irregular basis to other locations in North Carolina, Tennessee, and Georgia. The Service estimates that the Wolf Creek NFH has a direct economic benefit of $50 million annual and an indirect benefit of over $75 million. It returns almost $8 in tax revenues for every tax dollar spent. These benefits include employment, employment income, industrial output, and federal and state tax revenue that occur as the result of consumer expenditures on hatchery-related goods and services.

We have the following recommendations that would reduce impacts to our operation of the Wolf Creek NFH:

1. In order to maintain the hatchery with current infrastructure in place, two mechanical issues need to be addressed that would provide a temporary, interim solution to the water quality and quantity problems the Wolf Creek NFH is experiencing as a result of the Corps' draw-down. First, an automatic switching system is needed for the emergency pumps. There are two pumps, which are being used one at a time with no automatic mechanism to engage the second pump if the first pump fails. This arrangement makes it more likely that a major fish kill could occur if there is a pump failure. Second, repairs are needed to the existing multilevel intake manifold. The hatchery is currently getting some of its water from an uncontrollable point, which affects our ability to operate the hatchery.

2. Instead of the temporary solution above, a long-term solution that could eliminate the need for the temporary pumping system for the remainder of the project would involve (a) the installation of a modern aeration/oxygen system on the hatchery water supply, using the latest technology available that meets hatchery needs, and (b) the extension of the hatchery intakes to deeper levels of Lake Cumberland in order to access cooler water.

3. The hatchery stream could be rehabilitated or expanded to increase its use by fishermen. This stream is the most heavily fished stream per stream mile in Kentucky. This action would partially offset or mitigate the loss of recreational fishing opportunities on the lake and tailwater during the project and the possible longer-term effects on the fishery.

4. The Corps should also consider funding the construction and short-term operation (i.e., 5 years) of a small facility for holding and propagating rare and endangered. This would help address effects to non-game fisheries, especially federally listed species.

If you have any questions regarding these comments, please contact me or Leroy Koch of the Kentucky Field Office at 502/695-0468.

Sincerely,

Virgil Lee Andrews

Virgil Lee Andrews, Jr.
Field Supervisor

DEPARTMENT OF THE ARMY
NASHVILLE DISTRICT, CORPS OF ENGINEERS
P. O. BOX 1070
NASHVILLE, TENNESSEE 37202-1070

DEC 13 2007

IN REPLY REFER TO
Project Planning Branch

Mr. Lee Andrews, Field Supervisor
US Fish and Wildlife Service
330 West Broadway, Suite 265
Frankfort, Kentucky 40601

Dear Mr. Andrews:

This is in response to your letter of December 7, 2007, regarding agency comments on the *Wolf Creek Dam/Lake Cumberland Emergency Measures in response to Seepage Draft Environmental Impact Statement*. As you are aware, Wolf Creek Dam's foundation has shown signs of serious seepage problems. To minimize the risk to downstream populations, an emergency was declared and Lake Cumberland was drawn down to elevation 680 feet. The Corps is striving to maintain this elevation until repairs can be effected and the lake is returned to its normal operating regime.

The Corps has developed a decision making process to decide at what pool level Lake Cumberland would be held. This decision making process will be used at different points in time for the duration of the construction project regardless of alternative chosen. Examples of key decision points are: completion of the upstream grout line (estimated Early 2008), completion of the downstream grout line (estimated September 2008), completion of the cut-off wall in Critical Area 1 (estimated September 2009), etc. The process will be based on the completion of these structural measures and validated by performance indicators and continued overall stability and improvement in Wolf Creek Dam. The performance indicators are: the continued stable, downward trend of Piezometer readings, continued stable trend of wet spots, no anomalies in monitored settlement, and no anomalies based on visual inspections. This information will be used by a vertical team and a Corps advisory panel to make recommendations on incremental pool level changes of no more than 10 feet at a time.

The Biological Assessment (BA) presented in the Draft EIS has been revised significantly. Based on comments received from the Cookeville, Tennessee US Fish and Wildlife Service (Service) office for a BA on a similar project at Center Hill Lake, we have revised our determinations on species of concern. Of the 42 species in the potential area of impact we believe 35 would not be affected. Seven species were given a "May affect, but not likely to adversely affect" determination.

Some specific issues raised in the December 7, letter are as follows:

Several areas of critical habitat exist in tributaries above Lake Cumberland. There was concern expressed about lake level reductions causing destabilization of stream channels, head cuts, etc. The lake is routinely lowered every year and has not previously caused significant erosion problems in the tributaries. The Corps does not believe that a lower lake level would cause or contribute to any additional erosion and would not, therefore, adversely affect any of the critical habitats within these tributaries.

One potential cause for concern is if previously submerged cave openings become exposed and are used by federally-listed bats. This is considered unlikely because even though the Corps will be trying to maintain the lake at specific pool elevations, experience has shown that large rain events can raise the lake levels radically within a 24 to 48 hour period, which subjects any caves to similar historic flood frequencies. The Corps commits to surveying the exposed shoreline for any caves that appear to be suitable for occupation. If caves are found to be inhabited, the Corps will consult with the USFWS to determine the best method of relocating and/or excluding bats from the cave/s. In this way any potential entrapment of bats would be avoided.

The Service expressed concern for potential impacts to federally listed mussel species mostly below Cordell Hull Dam between Cumberland River Miles 264 and 308. The Corps operates the Cumberland River Reservoirs and associated tributary reservoirs as a single system. Water managers believe that with spilling water through the mainstem tainter gates rather than by generating hydropower, they can maintain dissolved oxygen levels to meet or exceed state standards. The Corps therefore believes there will be minimal adverse impact to mussel fauna below Cordell Hull Dam. Also, the Corps has been consulting with Tennessee Wildlife Resources Agency and has requested approval and funding for development of a Cumberlandia Non-Game Aquatic Species Refugia and Conservation Facility. This facility would have goals of providing a refugia, conservation, and propagation for freshwater mussels, aquatic snails, non-game fish, and other aquatic species.

The Service expressed concern for impacts to the Wolf Creek National Fish Hatchery. The Corps has been and will continue to work closely with the USFWS to minimize impacts to the hatchery. Two temporary auxiliary pumps, to provide additional cold water from the tailwater, were installed with the intention of maintaining one in operation and one as a backup, both of the pumps are currently being operated full time during the day and one pump at night. An alarm system has been installed to alert both the USFWS and the Corps in the event of a pump failure. The dam's control room is staffed at all times. Should there be a pump failure the second pump would be started manually. The Corps has also been consulting with the USFWS regarding the multi-level intake structure. Prior to the lowering of Lake Cumberland the structure was upgraded by the Corps as part of a project funded by USFWS. In January 2008, divers are scheduled to initiate work to repair a leak in the structure and to replace malfunctioning valves inside the dam. No decision has been made to determine if the structure will be lowered. Funding and approval has been requested by the Corps to rehabilitate and/or expand the hatchery stream. Neither has been received to date.

The first 75 miles below Wolf Creek Dam provides a unique coldwater fishery. Minimum releases have been maintained in the tailwater. Studies have been conducted to determine the optimal minimum flows below the dam and the Corps is fabricating and installing orifice gates over the sluice gate entrances to better regulate minimum flow releases. These orifice gates will provide a mechanism to provide a continuous minimum flow of approximately 500 cfs. These new gates offset short-term impacts and provide support of the coldwater fishery downstream of the dam by supplying a constant supply of well oxygenated water that meets or exceeds the state water quality requirements.

We have included a compact disc containing 2007 water quality data for the Cumberland River Reservoir System. This data shows the effects of the extreme drought in combination with lowered Lake Cumberland water levels. We have also included a copy of the Final EIS for your review.

We appreciate your comments and recommendations and look forward to our continued coordination. If you have further questions, feel free to contact Chip Hall, (615) 736 7666 or myself (615) 736-7865.

Sincerely,

Patricia L. Coffey
Chief, Project Planning Branch

Enclosures

<u>Appendix E</u>

Cumberland River Basin
Reservoir System
Water Management Operating Plan
During Interim Pool Restrictions at
Wolf Creek and Center Hill Dams

August 24, 2007
Version 1.2

Cumberland River Basin Reservoir System Water Management Operating Plan During Interim Pool Restrictions at Wolf Creek and Center Hill Dams

Nashville District Corps of Engineers
Nashville, Tennessee

August 2007

Cumberland River Basin
Reservoir System
Water Management Operating Plan
During Interim Pool Restrictions at
Wolf Creek and Center Hill Dams

Table of Contents

Table of Contents

Cumberland River Basin Reservoir System Water Management Operating Plan During Interim Pool Restrictions at Wolf Creek and Center Hill Dams

1. Background

1.1. Purpose and Scope. The Corps of Engineers (CE) has implemented interim water control operating restrictions at both Wolf Creek Dam (Lake Cumberland) in Kentucky and Center Hill Dam in Tennessee. Wolf Creek and Center Hill are both experiencing foundation seepage issues that have led the CE to implement a number of risk reduction measures. These pool restrictions are the latest and most significant of these actions. The lower lake levels associated with these actions will reduce the hydrostatic pressure on the foundation and lower the frequency of high lake levels, thus reducing risk at both projects. These interim water control operating restrictions are considered to be dynamic in nature and are subject to modification based on observed conditions. The interim operating restriction at Wolf Creek in 2007 is to operate for a year-round target elevation of 680. Likewise, in 2007 Center Hill has been operated to follow the lower band of the Southeastern Power Administration (SEPA) power marketing zone within the hydropower pool. The operating restrictions at each project will be evaluated periodically as construction progresses. Future lake level restrictions may be more or less stringent than those adopted for 2007. The water management operational guidance outlined in this plan will be in effect until circumstances or data indicate that a different approach is warranted.

1.2. Cumberland River Basin Reservoir System.

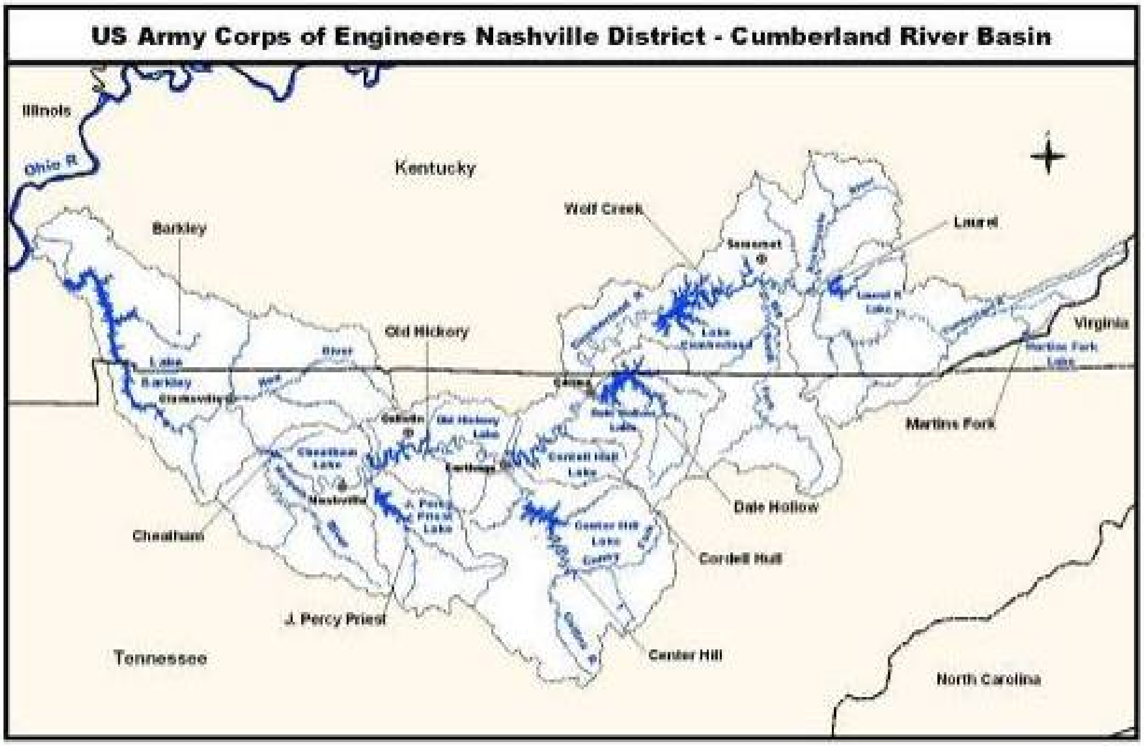
1.2.1. The Cumberland River Basin Master Water Control Plan (dated December 1998) has several general objectives for operation of the system of ten multipurpose water resources projects within the Cumberland River Basin. See Figure 1.

- To provide a significant volume to store flood waters and thereby reduce downstream flood peaks and associated flood damages, particularly at the four damage centers: Celina, Carthage, Nashville, and Clarksville, Tennessee, and also on the lower Ohio and Mississippi Rivers.
- To provide a significant volume to store water for the generation of hydropower at times of peak electrical demand.
- To provide a nine-foot channel depth for commercial navigation from the mouth of the Cumberland River to mile 381 at Celina, Tennessee.
- To provide a series of lake impoundments for the recreational enjoyment of the general public.
- To maintain a minimum reservoir level to offset lake sedimentation, to sustain adequate depths of cover for water supply intakes, to maintain permanent habitat for fish, and to reserve water for severe drought emergencies.

- To provide a sufficient flow of water in the system to enhance water quality for public consumption and aquatic life, and to maintain the availability of water for municipal and industrial users.

Figure 1

Cumberland River Basin Reservoir System



1.2.2. The ability to meet these operating objectives will be challenged by the impacts that these pool restriction requirements will impart on the system. Real-time reservoir system management requires a great deal of judgment in operation. It is recognized that the demands of water resource management are at times conflicting and the water control manager must have some degree of operational flexibility. Depending on the objectives of reservoir operations, the ten multipurpose projects in the Cumberland River Basin can be considered to operate as a unified system, as sub groups of the system, or as individual projects. This plan will outline how project and system operations may be impacted during this period of pool restrictions. The actual system operations will reflect how rainfall, temperature, and other outside influences have altered the water management capabilities of the Cumberland Basin Reservoir System.

1.2.3. The Cumberland River Basin receives an average of 51.64 inches of rainfall per year. Likewise, the average observed runoff generated by this rainfall is 21.82 inches. As noted in Table 1, rainfall and runoff are not evenly distributed over the course of a year.

Table 1

Average Rainfall and Runoff
For the Cumberland River Basin

Month	Rainfall (inches)	Runoff (inches)
January	4.75	3.47
February	4.30	3.43
March	5.75	4.07
April	4.61	2.84
May	4.52	1.87
June	4.18	0.93
July	4.45	0.67
August	3.70	0.47
September	3.75	0.38
October	2.80	0.34
November	4.08	1.07
December	4.75	2.28
TOTAL	51.64	21.82

1.2.4. It is this uneven distribution of runoff that has lead to the current reservoir system operation. Runoff is captured during the late winter and spring in the tributary storage projects (Wolf Creek, Dale Hollow, and Center Hill) and subsequently released during the typically dry summer and fall. Wolf Creek and Center Hill are the two largest storage projects in the Cumberland system. The 2007 pool restrictions will reduce the volume of water in storage by almost two-thirds. Environmental and water resources development within the Cumberland River Basin is dependent on the storage of a large volume of cold water at these projects. Water supply, water quality, fish and wildlife, operation of fossil fuel plants, recreation, and navigation are being impacted by these pool restrictions. The reservoir system will continue to be operated to provide flood control benefits, but the manner in which that is done will also change. Of the ten multipurpose projects within the Cumberland River Basin Reservoir System, Martins Fork will be the only project not impacted by these operating restrictions.

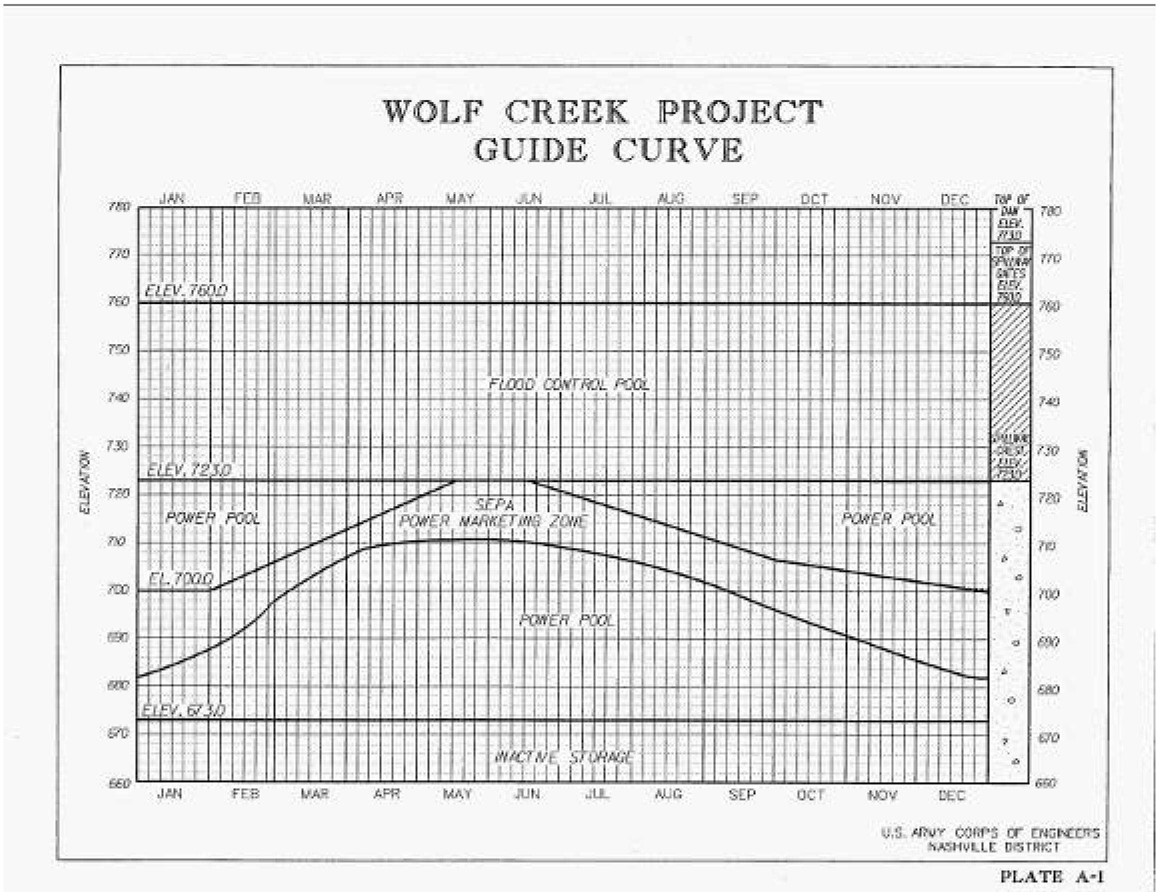
1.3. Wolf Creek.

1.3.1. Wolf Creek Dam was authorized by the Flood Control Act of 1938 and the River and Harbor Act of 1946 to provide flood control and hydropower benefits. Wolf Creek Dam is located on the Cumberland River at mile 460.9. The last of six 45-MW hydropower units was brought on line in August 1952. In addition to its originally authorized project purposes, the Wolf Creek project provides water supply, water quality, recreation, fish and wildlife, and drought mitigation benefits to the region. Wolf Creek has a drainage area of 5,789 mi^2, making it the largest tributary storage project within the Cumberland River Basin System. Lake Cumberland has an average depth of 80 ft and an average discharge of about 9,000 cfs. Wolf Creek is operated as part of the overall

Cumberland River Basin Reservoir System according to an established guide curve. See Figure 2.

Figure 2

Wolf Creek Project Guide Curve



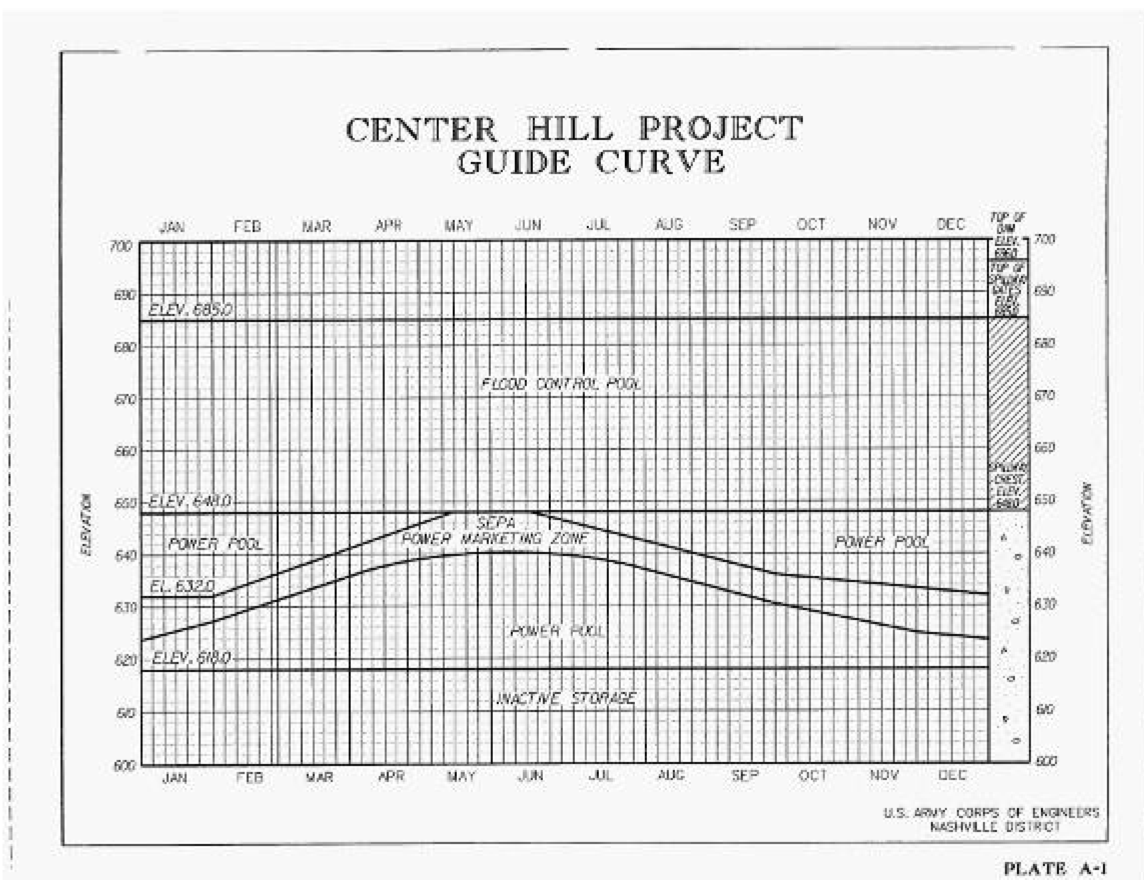
1.3.2. The hydropower pool extends from the top of the conservation pool elevation of 673 ft National Geodetic Vertical Datum (NGVD) of 1929 to elevation 723 ft. The flood control pool extends from 723 ft to 760 ft. The pool of record occurred in May 1984 when the lake reached elevation 751.7 ft. There is a seasonal operating guide within the power pool known as the SEPA power marketing zone. This operating zone was developed by SEPA, working closely with representatives from the Tennessee Valley Authority (TVA) and the CE. The SEPA power marketing zone starts the year low in the power pool, fills through the spring reaching the top of the power pool by summer, and then gradually falls through the summer and fall in time for the flood season. This is a non-binding operating guide that maximizes hydropower benefits while also supporting flood risk management, water quality, navigation, and other downstream uses dependent on the release of stored water through the summer and fall. The normal operation at Wolf Creek is to favor the top of the SEPA power marketing zone, targeting a June 1 elevation of 723 ft. The 2007 risk reduction measure for Wolf Creek Dam is to target a year-round elevation of 680 ft. This operation will reduce the volume of water stored in the hydropower pool by about 1,885,000 acre-feet (88.0%), and will severely impact both project specific and system operations.

1.4. Center Hill.

1.4.1. Center Hill Dam was authorized by the Flood Control Act of 1938 and the River and Harbor Act of 1946 to provide flood control and hydropower benefits. Center Hill Dam is located on the Caney Fork River at mile 26.6. The last of three 45-MW hydropower units was brought on line in April 1951. In addition to its originally authorized project purposes, the Center Hill project provides water supply, water quality, recreation, fish and wildlife, and drought mitigation benefits to the region. Center Hill has a drainage area of 2,174 mi^2, making it second only to Wolf Creek in terms of flood risk management capability. Center Hill Lake has an average depth of 73 ft and an average discharge of about 3,800 cfs. Center Hill is operated as part of the overall Cumberland River Basin Reservoir System according to an established guide curve. See Figure 3.

Figure 3

Center Hill Project Guide Curve



1.4.2. The hydropower pool extends from the top of the conservation pool elevation of 618 ft up to elevation 648 ft. The flood control pool extends from 648 ft up to 685 ft. The pool of record occurred in May 1984 when the lake reached elevation 681.5 ft. Within the power pool, the SEPA power marketing zone starts the year low in the power pool, fills through the spring reaching the top of the power pool by summer, and then gradually falls through the summer and fall in time for the flood season. This is a non-binding operating guide that maximizes hydropower benefits while also supporting flood risk management, water quality, navigation, and other downstream uses dependent on the release of stored water through the summer and fall. The normal operation at Center Hill is to favor the top of the SEPA power marketing zone, targeting a June 1 elevation of 648 ft. The 2007 risk reduction measure for Center Hill Dam is to follow the lower band of this zone, thus targeting a June 1 elevation of 640.6 ft. This operation will reduce the volume of water in storage by about 131,000 acre-feet (26.6%), but will retain some operational flexibility to support project and downstream water management objectives.

1.5. National Environmental Policy Act (NEPA) Considerations.

1.5.1 The CE is preparing Draft Environmental Impact Statements (DEIS) to address operational changes at Wolf Creek Dam and Center Hill Dam. The two DEIS are necessary to provide NEPA compliance to address changes that could include, but are not limited to, water quality, aquatic, riparian, and terrestrial habitat, recreation, water supply, flood storage, economics, hydropower production, and safety as a result of operating Lake Cumberland (Wolf Creek) and Center Hill Lake below normal pool elevations for extended periods of time. NEPA requires that prior to making any decision that would entail any irreversible and irretrievable commitment of resources, a Federal agency shall consult with and obtain the comments of any Federal agency which has jurisdiction by law or special expertise with respect to any environmental impact involved, and shall solicit public input and comment. Notices of Intent have been issued for both projects to initiate the NEPA process.

2. System Operations

2.1 Drought Contingency Planning.

2.1.1 The pool restrictions at Wolf Creek and Center Hill have the effect of placing the Cumberland River Basin Reservoir System in a severe hydrologic drought. In fact, flow conditions will be more limited than any seen during operation of the developed reservoir system. From early 1985 through most of 1988, the Cumberland Basin experienced a severe drought; however, even in 1988 during the fourth year of that drought Lake Cumberland was filled to an elevation of 711.77 ft, about 32 ft higher than the 2007 criteria. Likewise, in 1988 Center Hill was filled to elevation 642.34 ft, about two feet above the bottom of the SEPA power marketing zone. The CE applied lessons learned from the 1985-1988 drought to develop an operating policy for drought conditions. The final product of this evaluation was the Cumberland River Basin

Drought Contingency Plan, published in November 1994. Prior to the drought in the 1980s there was not an effective drought contingency plan in place, making system operations during the drought problematic and often contentious. The 1994 drought contingency plan, coupled with recommendations developed in this plan, will form the basis for how the Cumberland River Basin Reservoir System will be operated during these pool restrictions. The established system regulation priorities are as follows.

1. Water Supply
2. Water Quality
3. Navigation
4. Hydropower
5. Recreation

2.1.2. These priorities are consistent with the logic that led to development of the pool restrictions where public health and safety was the overall guiding principle. In fact, dam safety and flood risk management considerations over-ride any other operating objectives. Otherwise, each of the operating objectives will be addressed both individually and from a system perspective. Because the pool restrictions impact the entire Cumberland River system, it will be necessary to have control points to monitor the effectiveness of the system operating plan.

2.2. Control Points. While it is desirable to develop overall water management objectives, it is not practical to apply fixed operating rules. The day to day reservoir system operations will be highly dependent on meteorological conditions, specifically the amount and distribution of rainfall and observed air temperature. System conditions will be evaluated on a daily basis and a forecast will be developed consistent with the overall system operating objectives. The existing precipitation, stream flow, and water quality remote monitoring network is designed for routine system operations. It will be supplemented as necessary to collect the information needed to develop the best possible forecasts. A number of Cumberland River Basin control points have been identified that will serve as overall guides for system operations. The system will be managed for these control points through application of the system priorities contained within the drought contingency plan. It is anticipated that these control points will be dynamic in nature, with one or more factors influencing system operations at any given time. It will remain imperative that water managers retain a reasonable degree of flexibility to be able to react to changing conditions. The Cumberland Basin control points are as follows (presented from upstream to downstream):

- John Sherman Cooper Power Plant
    - Maintain adequate supply of cooling water
- Lake Cumberland municipal and industrial water supply intakes
    - Maintain adequate pool level (680 ft)
- Lake Cumberland cold water budget
    - Protect coldwater fisheries in lake and tailwater
    - Project release objective: 6 mg/l dissolved oxygen
- Wolf Creek National Fish Hatchery

- Provide continuous supply of cold water

- Cumberland County, KY and Burkesville, KY water supply
  - Provide 500 cfs minimum mean daily release from Wolf Creek
- Dale Hollow cold water budget
  - Protect coldwater fisheries in lake and tailwater
- Cordell Hull project releases
  - Project release objective: 5 mg/l dissolved oxygen
  - Schedule releases to support navigation below Cordell Hull
  - Schedule releases to support TVA Gallatin Fossil Fuel Plant
- Center Hill cold water budget
  - Protect coldwater fisheries in lake and tailwater
  - Project release objective: 6 mg/l dissolved oxygen
  - Schedule releases to support TVA Gallatin Fossil Fuel Plant
- TVA Gallatin Fossil Fuel Plant
  - Provide cooling water flow – 1,300 cfs
  - Threshold temperature – 24.4 ^{o}C (76 ^{o}F)
- Old Hickory project releases
  - Project release objective: 5 mg/l dissolved oxygen
  - Schedule releases to support navigation below Old Hickory
- J. Percy Priest project releases
  - Project release objective: 5 mg/l dissolved oxygen
- Cheatham project releases
  - Project release objective: 5 mg/l dissolved oxygen
  - Schedule releases to support navigation below Cheatham
  - Schedule releases to support TVA Cumberland Fossil Fuel Plant
- TVA Cumberland Fossil Fuel Plant
  - Provide cooling water flow – 4,000 cfs
  - Threshold temperature – 29.4 ^{o}C (85 ^{o}F)
- Barkley Canal
  - Manage Canal flows to support TVA Cumberland operations
- Barkley and Kentucky project releases
  - Project release objective: 5 mg/l dissolved oxygen
  - Schedule releases to support navigation below Kentucky and Barkley
  - Ohio & Mississippi River flood risk management operations
  - Ohio & Mississippi River navigation concerns

2.3. Water Supply.

2.3.1. Lake Cumberland Municipal and Industrial Water Supply Users. The system will be operated to maintain a reliable and usable supply of water for both municipal and industrial users as hydrometeorological conditions permit. There are several municipal and industrial water supply users on Lake Cumberland with intakes located between the bottom of the power pool (673 ft) and the 2007 target elevation of 680 ft.

2.3.2. John Sherman Cooper Power Plant. The most vulnerable of these intakes is the one for the John Sherman Cooper Power Plant positioned at elevation 675 ft. This facility, that supplies power to over one million customers in Kentucky, experiences substantial reduction in megawatt production, depending on the water temperature in Lake Cumberland, at elevation 680 ft. Additional derates would be required for lake elevations below 680 ft. Once the lake elevation decreases to 675 ft John Sherman Cooper would be unable to generate power.

2.3.2. Cumberland County, KY and Burkesville, KY Water Supply Intakes. Burkesville, Kentucky and adjacent areas within Cumberland County represent the first concentrated population centers downstream from Wolf Creek Dam. They withdraw water directly from the Cumberland River about 30-40 miles downstream from Wolf Creek Dam. Recently completed HEC-RAS modeling of this reach of the Cumberland River indicates that a minimum mean daily flow of around 500 cfs from Wolf Creek Dam will provide adequate water depth for these intakes. This flow is also supportive of downstream environmental requirements. The minimum mean daily flow from Wolf Creek Dam during normal operating conditions is 1,800 cfs.

2.3.3. A review of the historical record of inflows to Lake Cumberland indicates that flows often get very low during the June through November period. See Table 2. The long term (1953 – 2006) minimum monthly inflow for the months of July, August, September, October, and November are all negative, indicating that evaporation from the lake surface exceeded inflow from the tributary streams. As a result it may be problematic to maintain a 680 elevation in Lake Cumberland during periods of low inflow and high evaporation. Beginning in December, inflows begin to increase significantly due to the increased frequency of rainfall events, making it much easier to meet various operating objectives.

Table 2
Wolf Creek Project Inflow 1953 – 2006

Month	Minimum (Daily Avg. CFS)	Maximum (Daily Avg. CFS)	Mean (Daily Avg. CFS)	Median (Daily Avg. CFS)
January	721	41,592	15,409	14,770
February	3,417	50,760	17,798	15,887
March	5,763	54,764	18,989	15,378
April	1,883	34,603	14,683	13,685
May	2,182	37,601	9,368	7,019
June	108	20,730	5,240	3,256
July	-20	16,945	2,916	2,364
August	-182	10,652	1,863	1,127
September	-258	15,212	1,951	630
October	-266	17,780	1,960	1,027
November	-126	20,198	5,831	4,406
December	201	41,922	12,230	11,233

2.3.4. Center Hill Municipal and Industrial Water Supply Users. There are three water supply intakes on Center Hill. They are all located below the bottom of the power pool; therefore, an operational scenario where the target guide curve is to follow the bottom of the SEPA power marketing zone will not impact their operation. The Smith County Utility District has an intake on the Caney Fork River about 19 miles downstream from Center Hill Dam. With the seasonal storage provided by the SEPA power marketing zone there will not be any quantity related issues with this utility. This has been confirmed by HEC-RAS modeling completed for the Caney Fork River. The CE (Center Hill Lake Resource Management) routinely coordinates with staff at the water treatment plant when sluicing operations are initiated at Center Hill so that they can anticipate changes in raw water quality and adjust their treatment accordingly.

2.3.5. Mainstem / Lock and Dam Water Supply Users. There are multiple municipal and industrial water supply intakes along the Cumberland River within the Cordell Hull, Old Hickory, Cheatham, and Barkley pools. There are no plans to lower the headwater operating guidelines for these projects, thus there will be sufficient water available for their continued operation. It is anticipated that there will be changes in the quality of water available for treatment and that treatment costs will go up accordingly. Quality impairments will be a byproduct of reduced flows through the system during the summer and fall. Water users can expect to experience warmer water temperatures, reduced dissolved oxygen levels, increased algal activity with associated taste and odor issues, and increased concentrations of certain metals and nutrients. The reservoir system will be operated to support water quality for water supply to the extent practical given the impacts of the anticipated flow reductions.

2.4. Water Quality.

2.4.1. Water quality impacts may be observed at Wolf Creek and Center Hill as a direct impact of the lower lake levels and/or may occur many miles downstream as a result of release schedule modification. The direct project impacts would be related to changes to the cold water budget.

2.4.2. Water Temperature and Dissolved Oxygen at Wolf Creek. With an operational target of elevation 680 ft (2007 target elevation), Lake Cumberland will begin the summer with a significantly reduced volume of cold water in storage. The coldwater fisheries in the lake, primarily stripers and walleye, are dependent on the maintenance of a zone of cold, oxygenated water. Likewise, the tailwater fishery that includes rainbow and brown trout in addition to striper and walleye is dependent on the release of cold, oxygenated water. If the cumulative project releases through Wolf Creek Dam during the summer exceed the volume of cold water in storage, significant fish die-offs would be expected both in the lake and in the river below the dam. A late spring major storm event or a series of spring or summer storms would increase the likelihood of this happening. The only water management option available for the tailwater at Wolf Creek is to use sluice gate releases in lieu of hydropower releases to provide cold, oxygenated water for the tailwater. Sluicing will conserve the zone of cold water in the lake used by important fish species as long as adequate dissolved oxygen is available. This can be effective up to a point, but once the cold water is gone there is nothing that can be done to protect these fisheries.

2.4.3. Water Temperature and Dissolved Oxygen at Center Hill. Center Hill will face similar cold water budget challenges; however, since the (2007) drawdown there is not as severe as that for Wolf Creek, the risk to these fisheries is less. Sluice gate releases are also a viable option at Center Hill to manage for either lake or tailwater cold water issues.

2.4.4. Water Temperature and Dissolved Oxygen at Dale Hollow. While Dale Hollow does not have any imposed operating restrictions, cold water budget issues could arise due to the increased reliability on water pulled from storage at this project. Dale Hollow also has sluice gates with intakes located deep in the water column that can be used for temperature and/or dissolved oxygen management.

2.4.5. Water Temperature and Dissolved Oxygen at Laurel and J.Percy Priest. The revised operations at Wolf Creek and Center Hill should not have any water quality impacts to either Laurel River Lake or J. Percy Priest Lake. The existing spillway releases for water quality management, pending the availability of water, will continue to be employed at J. Percy Priest as needed for dissolved oxygen, metals, and taste and odor issues observed in the tailwater and at downstream water treatment plants.

2.4.6. Water Temperature and Dissolved Oxygen at Mainstem Projects. Water quality impacts are also expected at the main-stem Cumberland River projects (Cordell Hull, Old Hickory, Cheatham, and Barkley) as a result of the reduced flows moving through the system. The lower flows will increase the hydraulic residence time in each of these projects resulting in warmer water temperatures and lower dissolved oxygen levels. There is little that can be done for temperature since temperature impacts are a direct function of the flow (residence time) through the system and weather conditions. In 2007, with approximately two-thirds of the normal storage eliminated, the summer and fall flow regime will be significantly reduced. The option of releasing water through spillway gates at Cordell Hull, Old Hickory, Cheatham, and Barkley is available to increase dissolved oxygen concentrations. The State Water Quality Standard applicable at each of these projects is a minimum of 5 mg/l.

2.5.6. Based on past experience during drought conditions the Old Hickory project is the most likely main-stem project to experience dissolved oxygen problems. Also, when Lake Cumberland was drawn down in the 1970s for construction of the existing cutoff wall, extremely low dissolved oxygen levels were observed in hydropower releases from Old Hickory.

2.5.7. Prior to 2007, the Nashville District did not have any direct experience of using spillway releases to manage for dissolved oxygen at the main-stem projects. Prior to this year CE reaeration experts at the Waterways Experiment Station indicated that spillway releases are an effective means of aerating project releases. Their recommendation was to spread the flow out over several spillway gates to avoid spilling more than 1,000 cfs through any one gate. CE experience using this release scenario at similar projects has resulted in 85-90% dissolved oxygen saturation and total dissolved gas levels of around 110%. The results to date at projects along the Cumberland River (Cordell Hull, Old Hickory, and Cheatham) have been very favorable. Spillway releases have proven to be an effective method to provide water quality conditions supportive of downstream water treatment and aquatic environment conditions.

2.5.8. TVA operates coal fired power plants at Gallatin and Cumberland City that are dependent on the Cumberland River for cooling water flow. The cooling water for these plants originates in the Cumberland River Basin storage projects (Wolf Creek, Dale Hollow, and Center Hill) during the summer and early fall when natural flows in the Cumberland River are typically very low. Given the elimination of storage at Wolf Creek and the reduction of storage at Center Hill, maintenance of adequate cooling water flow (both quantity and temperature) will become a primary driver for water management operations.

2.5.9. TVA Gallatin Fossil Fuel Plant. The TVA Gallatin Fossil Fuel Plant is located in the Old Hickory pool and is downstream of the three primary storage projects. The cooling water requirement for this facility is 1,300 cfs. The threshold cooling water intake temperature for this facility is 24.4 ^{o}C (76 ^{o}F). The combination of this flow requirement, the physical layout of the intake and discharge structures, and the proximity of the Gallatin plant to upstream cold releases places this facility in a favorable position to maintain reliable service. Water temperature will be the primary concern for this facility.

2.5.10. TVA Cumberland Fossil Fuel Plant. The TVA Cumberland Fossil Fuel Plant, located in the Lake Barkley pool, will be a much bigger challenge with regard to cooling water requirements. Cumberland is significantly larger than Gallatin and has a cooling water requirement of approximately 4,000 cfs and a threshold intake temperature of 29.4 ^{o}C (85 ^{o}F). This plant has a history of cooling water issues during extended hot, dry periods. The plant discharge structure is located close enough to the intake that heated water can recirculate upstream and mix with the Cumberland River flow in the vicinity of the intake. When this occurs the plant must adjust operations to preclude violation of temperature permit requirements. The typical solution for this recirculation issue has been to forego hydropower peaking operations at Cheatham Dam and schedule a steady one unit use throughout the day. This translates to a flow of around 6,300 cfs. However, without the water in storage at the upstream projects there may not be enough water to run a continuous one unit schedule at Cheatham.

2.5.11. A joint TVA/Corps team has been established to work on this issue. TVA has the capability to model temperature impacts to the Lake Barkley project including the immediate TVA Cumberland area. TVA has also made physical modifications to their discharge facility to significantly reduce the amount of heated water from reaching their intake. The cooling water requirements for TVA Cumberland will play an important role in how the Cumberland Basin reservoir system is operated. Water in storage will be conserved to the extent practical during the spring and early summer to save it for use during the critical July, August, and September period. This will be accomplished by only releasing from storage the volume of water necessary to meet flow and temperature requirements at TVA Cumberland.

2.5.12. Wolf Creek and Center Hill will be operated according to the pool restriction criteria. The additional water needed to meet flow requirements will originate from Dale Hollow. This operation could result in higher lake levels than those typically observed in the spring and early summer at Dale Hollow. Likewise, depending on the rainfall pattern fall lake levels at Dale Hollow could be lower than normal.

2.5. Navigation.

2.5.1. A nine-foot commercial navigation channel on the Cumberland River is generally supported by the maintenance of full, flat pools and minimum tailwater elevations at the four main-stem projects. There are navigation impediments in the approaches to both Old Hickory and Cheatham that can effect navigation during low flow conditions. Navigation industry equipment and operations have evolved over time to match observed conditions on the Cumberland River. This includes the decision by some towing companies to run 10-ft draft tugs and to routinely run over-draft (> 9-ft) barges. These practices are due in large part to the water originating from Wolf Creek and Center Hill that augment Cumberland River flows during otherwise low flow periods. Currently, tows are dependent on favorable release schedules to transit reaches below the navigation projects. Their practice is to wait on windows of opportunity to navigate these critical reaches rather than reconfiguring their load to reduce their draft. There will need to be some project release scheduling considerations as well as adjustments by the shipping industry to maintain a reliable commercial navigation pattern during periods of low flow at the navigation projects.

2.5.2. <u>Impacts to Navigation due to Rapid Drawdowns.</u> A rapid drawdown at Wolf Creek and/or Center Hill, followed by severe reductions in discharge, creates abrupt river fluctuations that result in adverse navigation conditions. These adverse conditions extend from the lower approach to Cheatham Lock through the Nashville harbor and into the Old Hickory pool. The lock approaches to Cheatham and Old Hickory along with the main river channel through Nashville are critical areas for commercial navigation. A lower than normal Old Hickory pool elevation has a significant impact to recreational boating, but less of an impact to commercial navigation. Therefore, when lowering Wolf Creek and Center Hill lakes a smooth transition is critical to avoiding navigation impacts downstream.

2.5.3. <u>Impacts to Navigation at Barkley Dam, Kentucky Dam, Ohio River and Mississippi River.</u> Navigation conditions on the Cumberland River at Barkley Lock and Dam and on the lower Ohio River (Lock and Dam 52 and Lock and Dam 53) may be more severely impacted than those upstream along the Cumberland. The Cumberland below Barkley is dependent on either project releases or the Ohio River (Lock and Dam

52 pool) or a combination of both to maintain a minimum tailwater elevation (302) to support navigation. The reduction of storage within the Cumberland system will limit the ability to maintain elevation 302 when Ohio River levels are low. Releases from Barkley and Kentucky are often scheduled to support navigation concerns on the lower Ohio and Mississippi. This capability will be reduced due to the reduction of storage within the Cumberland system and could lead to impaired conditions on the lower Ohio and Mississippi.

2.5.4. The operation of Kentucky and Barkley dams involves complicated and often contradictory issues. Therefore, a predetermined plan to deal with low tailwater levels is not practical. The operational response to navigation conditions when Ohio River levels are low will require coordinated effort between LRD, LRL, LRN, and TVA.

2.6. Hydropower.

2.6.1. Hydropower generated at the Cumberland River Basin plants is marketed by the Southeastern Power Administration (SEPA). In a 1984 Memorandum of Understanding between SEPA, TVA, and the Corps of Engineers minimum weekly energy goals were established. Since that time the CE has an excellent track record of meeting these hydropower goals. See Table 3 for a listing of the minimum energy requirements.

Table 3

Cumberland Basin Projects
Weekly Minimum Energy

Month	Minimum Energy (MWH)
January	24,000
February	29,400
March	32,000
April	32,000
May	22,600
June	24,600
July	32,200
August	32,200
September	21,000
October	15,800
November	16,000
December	20,000

2.6.2. Without the water in storage at Wolf Creek and Center Hill it will not be possible to meet these minimum energy goals. The marketing strategy has been revised to reflect only the energy available for production based on water allocations. Power is now marketed on a daily basis instead of a weekly basis. With the loss of storage due to restrictions at Wolf Creek, the Cumberland River basin will begin each summer at threshold level four of the Cumberland River Basin Drought Contingency Plan. Therefore, the priority for hydropower falls below those for water supply, water quality, and navigation. While a significant amount of the releases at the projects will be through generation, the scheduling will be based on the needs of the higher priority purposes. During periods when the conditions permit, more significance will be given to optimizing for hydropower benefits.

2.6.3. An effort will be made at Laurel River Lake to hold higher summer pool elevations (not to exceed elevation 1018 ft) to support operation of the John Sherman Cooper Power Plant. This will require close coordination with SEPA and the East Kentucky Electric Cooperative.

2.7. Recreation.

2.7.1. The recreation impacts at Lake Cumberland and to a lesser extent Center Hill Lake have been well documented. Lake recreation tends to be elevation dependent. The revised operations at these projects coupled with recreation's priority within the operating objectives established in the drought contingency plan, leaves little in the way of operational flexibility to support recreation interests. The lake level at Laurel can be held higher in the summer without significantly impacting other project purposes including system flood risk management capabilities. This operation would have the added benefit of supporting lake based recreation.

2.7.2. Typical seasonal pool elevations will be maintained at the remaining Cumberland Basin projects. Water control actions implemented for water supply and water quality requirements will have the added benefit of supporting fish and aquatic life based recreational pursuits. Minimum daily project releases will continue to be made from the projects where they are required under the existing operating criteria. The relatively low summer and fall releases from Wolf Creek and Center Hill will enhance wade fishing opportunities in their tailwaters.

2.8. Flood Risk Management.

2.8.1. Even though the Cumberland Basin reservoir system will be operated following drought condition guidelines, the basin is never more than one storm event away from initiating flood risk management operations. Flood risk management will continue to be the over-riding priority for system operations.

2.8.2. Although the lower pools targeted at Wolf Creek and Center Hill will actually increase the flood storage capacity of the system, the operation necessary to consistently maintain these lower levels could compromise the flood risk management benefits of the additional storage capacity. Following a significant runoff producing event, priority will be given to Wolf Creek and Center Hill to evacuate water stored above their target elevations. This presents a couple of issues that have the potential to compromise overall system flood risk management capability. First, if a series of events come in close succession, there is the potential to accumulate water in the other projects to a level that impacts system operation. Second, if a follow up event hits the downstream uncontrolled portion of the basin in conjunction with an aggressive release pattern at Wolf Creek and/or Center Hill to reduce their storage, flood crests could be higher than otherwise experienced. This could occur at any of the Cumberland River damage centers (Celina, Carthage, Nashville, and Clarksville) or along the lower Ohio or Mississippi Rivers. The following tables will be used as a guide on how to evacuate storage at Wolf Creek and Center Hill. Downstream impacts will always be a primary consideration when setting release schedules.

Table 4

Guidelines for Evacuating Storage at
Wolf Creek Dam (Lake Cumberland)

Elevation	Criteria
Wolf Creek:	
0 – 3 ft above upper guide curve elevation	Operate for most efficient use of water.
3 – 5 ft above upper guide curve elevation	Ramp up to turbine capacity as necessary to hold within 5 ft of the upper guide curve elevation if downstream conditions permit.
5 – 10 ft above upper guide curve elevation	Generate at turbine capacity to keep within 5 ft of the upper guide curve elevation. If the pool is forecast to exceed the upper guide curve elevation by more than 10 ft supplement flows with sluice gate releases.
10 ft above upper guide curve elevation up to elevation 723	Combination of turbine capacity and sluice gate releases unless downstream conditions require reductions.
> 723	Combination of turbine, sluice, and spillway releases to manage according to established flood risk management criteria. Total flow not to exceed 40,000 cfs. Full coordination with LRD required if Ohio River flooding is ongoing.

Table 5

Guidelines for Evacuating Storage at
Center Hill Lake

Elevation	**Criteria**
Center Hill:	
0 – 3 ft above upper guide curve elevation	Operate for most efficient use of water.
3 – 5 ft above upper guide curve elevation	Ramp up to turbine capacity as necessary to hold within 5 ft of the upper guide curve elevation if downstream conditions permit.
5 – 10 ft above upper guide curve elevation	Combination of turbine capacity and sluice gate releases unless downstream conditions require reductions. Discharges should be managed to stay within the downstream channel capacity of 30,000 cfs.
10 ft or more above upper guide curve elevation	Combination of turbine, sluice, and spillway releases to manage according to established flood risk management criteria. Total flow in the Caney Fork River not to exceed 30,000 cfs. Full coordination with LRD required if Ohio River flooding is ongoing.

2.9. Operational Modifications at Cumberland Basin Projects in Addition to Wolf Creek and Center Hill.

2.9.1. The pool restrictions at Wolf Creek and Center Hill have the potential to impact operations at nine of the ten Cumberland Basin Projects. Martins Fork is the only project where no impacts are anticipated. For most of the projects the water control variants are more flow than lake level related; however, there will be a conscious effort to target higher pool elevations at some projects. In all cases where higher headwater elevations are targeted this can be done without significantly compromising system flood risk management capabilities.

2.9.2. Laurel. Laurel has an uncontrolled spillway at elevation 1018.5 ft, and does not provide any flood risk management benefits. The top of the SEPA power marketing curve is at elevation 1018 ft. LRN will work closely with SEPA and the East Kentucky Power Electric Cooperative to target early summer lake levels higher than those typically observed (but not to exceed 1018 ft). The purpose of this operation is to support cooling water operations at the John Sherman Cooper Power Plant during the critical summer and early fall period.

2.9.3. Dale Hollow. The top of the power pool at Dale Hollow is elevation 651 ft. LRN will target a 1 June elevation of 653 ft at Dale Hollow, thus placing two feet of water on the spillway gates and reducing the flood control pool by 15.9 %. This water will be conserved to the extent practical to support downstream water supply, water quality, and navigation requirements along the main-stem Cumberland River projects. Given the ratio of project storage to drainage area, Dale Hollow will be very difficult to overfill under dry conditions (when the extra water would be the most valuable).

2.9.4. Mainstem Lock and Dams. A concerted effort will be made to hold the Cumberland River main-stem projects (Cordell Hull, Old Hickory, Cheatham, and Barkley) near the top to slightly over the top of the stated power pools when possible. The Cumberland River is flashy in nature; a condition that will be amplified due to the run of the river run operations adopted at Wolf Creek. This has the potential to create dramatic (relative to normal operations) swings in elevation along the navigable stretch of the Cumberland River. The maintenance of favorable conditions for commercial navigation is particularly vulnerable to sudden reductions in flow such as those created by operating for a fixed elevation at Wolf Creek. Since the overall dynamics of the main-stem system are difficult to predict under transitional flow regimes, this added water will be used as a buffer when conditions require.

2.9.5. Cordell Hull. The fill to summer pool at Cordell Hull may require additional time and thus needs to begin earlier in order to capture water when available while still passing enough flow to meet downstream requirements. When necessary, the early fill will start at the beginning of April instead of the middle of the month. It may also be necessary to fill Barkley and Kentucky pools early; however, that is a joint decision between LRD, LRN, and TVA since it involves three separate river systems.

3. Communication and Coordination

3.1. Nashville District Water Management. The Nashville District Water Management Office coordinates daily with LRD Water Management, TVA River Operations, SEPA, National Weather Service, LRN Power Plant Operators, and members of the public. Automated data exchange procedures are in place with water management partners and stakeholders. The water management impacts of the revised Wolf Creek and Center Hill operations will require increased communication and coordination efforts in terms of the addition of individuals and groups and also to the frequency of information exchange. The following table summarizes stakeholders, organized by prioritized project purpose, that LRN Water Management has been in contact with since the pool restrictions were announced. This list is considered dynamic in nature and will be supplemented as this process evolves.

Table 6

Water Management Customers
Organized by
Drought Contingency Plan Prioritized Purpose

Agency or Group	Issue
Water Supply:	
Lake Cumberland water supply users	Impacts of lake level on water supply intakes.
Kentucky Division of Water (KDOW)	Water quality impacts to water supply.
City of Burkesville	Low flow impact to raw water intake.
Tennessee Department of Environment and Conservation (TDEC)	Water quality impacts to water supply.
Tennessee Wildlife Resources Agency (TWRA)	Water quality impacts of flow modifications to fish and aquatic resources.
East Kentucky Power Cooperative (EKPC)	Cooling water at John Sherman Cooper Power Plant.
TVA Fossil Fuel Plants	Cooling water at Gallatin and Cumberland.
TVA Environmental Compliance	Cooling water at Gallatin and Cumberland.
Metro Nashville	Water quality impacts to water supply.
Water Quality:	
Kentucky Department of Fish and Wildlife Resources (KDFWR)	Impacts to the coldwater budget in Lake Cumberland and the river below.
Kentucky Division of Water (KDOW)	Impacts to the coldwater budget in Lake Cumberland and the river below.
U. S. Fish & Wildlife Wolf Creek National Fish Hatchery (USFWS)	Supply of cold water to the Wolf Creek National Fish Hatchery.
Tennessee Department of Environment and Conservation (TDEC)	Impacts to the Cumberland River impoundments in Tennessee.
Tennessee Wildlife Resources Agency (TWRA)	Fishery impacts at Center Hill and Cumberland River projects and impacts to native mussels in Cumberland River.
Metro Nashville	Impacts of water quality changes to wastewater treatment plant operations.
Trout Unlimited (TU)	Impacts to cold water fisheries.
Ohio Valley Fly Rod Club	Impacts to cold water fisheries.
Navigation:	
U. S. Coast Guard	Impacts to commercial navigation resulting

	from reduced flows in the system.
Navigation Industry	Impacts to commercial navigation resulting from reduced flows in the system.
Hydropower:	
Southeastern Power Administration (SEPA)	Impacts to power marketing agreements.
TVA River Operations	Impact of revised system operations on hydropower production.
TVA Power Scheduling	Hourly scheduling of hydropower.
East Kentucky Power Cooperative (EKPC)	Hydropower scheduling at Laurel River Lake.
Team Cumberland	Impact of revised system operations on hydropower production.
Recreation:	
Kentucky Department of Fish and Wildlife Resources (KDFWR)	Impact of Wolf Creek drawdown on fishing and boating opportunities.
Tennessee Wildlife Resources Agency (TWRA)	Impact of Wolf Creek and Center Hill drawdowns on fishing and boating opportunities.
Marina Operators	Impact of lake level revisions on marina operations.
Trout Unlimited (TU)	Impacts to cold water fisheries.
Ohio Valley Fly Rod Club	Impacts to cold water fisheries.
Middle Tennessee Amateur Retriever Club	Impact of pool restrictions on system operations.
Commercial Fishermen	Impact of pool restrictions on system operations.

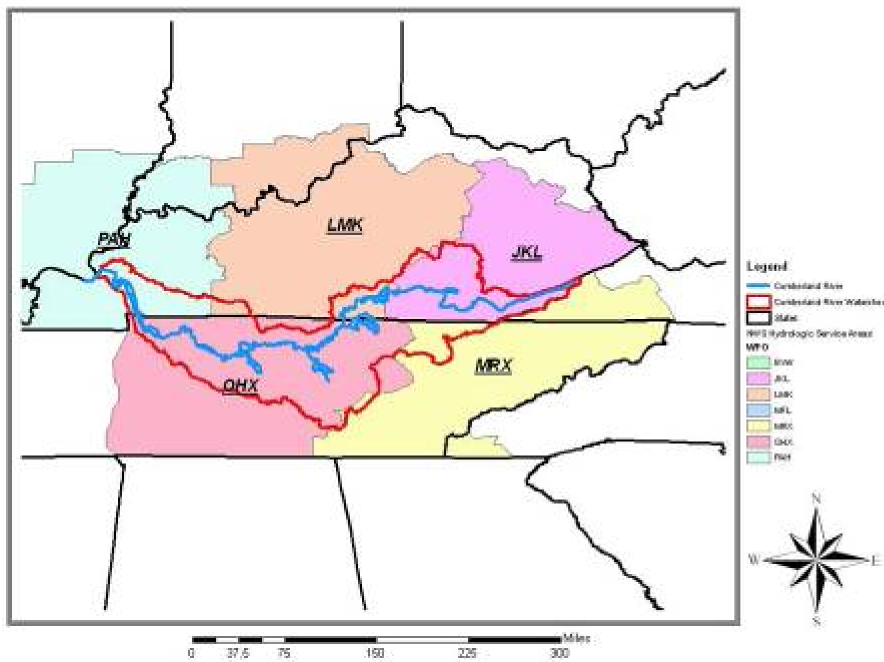
3.2. National Weather Service Coordination.

3.2.1. CE partners closely with the National Weather Service (NWS) and provides the agency with daily river and reservoir observations (flow and stage) and reservoir release schedules. The observations and reservoir release schedules are integral to the production of the NWS hydrologic forecasts. This information is transmitted daily from the Nashville District (and the other Ohio River District offices) in automated SHEF-encoded reports to the Division office (LRD) located in Cincinnati, Ohio. Data is then exchanged with the NWS Ohio River Forecast Center (OHRFC) in Wilmington, Ohio via a dedicated communication line.

3.2.2. The OHRFC has the primary responsibility for producing and disseminating stage and flow forecasts of the Ohio River and its tributaries. The OHRFC provides the forecasts to local Weather Forecast Offices by hydrologic service area

(HSA) for the issuance of flood watches and warnings to the public. Four HSAs primarily encompass the Cumberland River System. The service areas and river system are shown in Figure 4.

Figure 4
National Weather Service
Hydrologic Service Areas



3.2.3. During flood events on the lower Ohio and Mississippi Rivers, LRD communicates closely with the OHRFC and two other RFCs, the Lower Mississippi River Forecast Center (LMRFC) and the North Central River Forecast Center (NCRFC). The junction point for this delineation is located at Dover, TN, approximately Cumberland River Mile 89. Under Section 7 of the Flood Control Act of 1944, LRD directs the operations of Nashville District’s Lake Barkley, and the Tennessee Valley Authority’s Kentucky Lake, to reduce flood crests with the primary objective of preserving and protecting the Mississippi River levee system. LRD communicates closely with the RFCs in the production of the public river forecasts.

3.2.4. During the interim period, established data flow and communication procedures will continue. However, if the Wolf Creek release schedule should significantly change after the normal transmission time to LRD, the reservoir scheduler should inform LRD Water Management. If LRD cannot be reached, the Ohio River Forecast Center should be contacted directly. See Table 6 below for information for the various water control centers associated with Cumberland River Basin system operations.

Table 7

Water Control Centers

Office	Office Phone and Hours	Non-Duty Phone
LRD Water Management	(###) ###-#### 7:00 a.m. – 4:00 p.m.	(###) ###-####
LRN Water Management	(###) ###-#### 7:30 a.m. – 4:00 p.m.	(###) ###-####
TVA River Operations	(###) ###-#### 24-hour operation	(###) ###-####
Ohio River Forecast Center	(###) ###-#### 6:00 a.m. – 10:00 p.m.	(###) ###-####
Lower Mississippi River Forecast Center	(###) ###-#### 6:00 a.m. – 10:00 p.m.	

3.2.5. During flooding on the Cumberland System, LRN Water Management should maintain close contact with LRD Water Management, the NWS Ohio River Forecast Center, and the NWS Service Hydrologists for the four HSAs to keep all informed as to the flood control strategy. Should the strategy significantly change during the day invalidating the NWS publicly issued forecasts, LRN Water Management should notify the Service Hydrologists in addition to LRD and the OHRFC. NWS contact information is presented in Table 7.

Table 8

Contact Information for the
National Weather Service

Hydrologic Service Area	Service Hydrologist or Focal Point	Office Phone	Operations Desk Phone (24 x7)
LMK	**********, Louisville, KY WFO	(###) ###-####	(###) ###-####
JKL	********** Jackson, KY WFO	(###) ###-####	(###) ###-####
OHX	********** Nashville, TN WFO	(###) ###-####	(###) ###-####
PAH	********** Paducah, KY WFO	(###) ###-####	(###) ###-####
LCH	********** Slidell, LA WFO	(###) ###-####	(###) ###-####

3.2.6. When a lower Ohio flood control operation is in effect, decisions regarding Wolf Creek releases and other Cumberland System reservoirs must be coordinated with LRD Water Management to ensure that all system regulation objectives are met to the extent possible. This coordination must take place before Wolf Creek release decisions are effected, unless under conditions of imminent dam failure. This coordination should occur during the regularly scheduled flood coordination call at 8:30 a.m. Eastern time (7:30 a.m. Central) between LRD and LRN. In the event of an imminent dam failure, communication procedures as specified in the Wolf Creek Dam Emergency Operations plan are followed. A multi-agency phone list is presented in Table 9.

Table 9

Water Management Phone List

Position	Name	Office	Home
LRN Water Management:			
Chief, H&H Branch	**********	(###) ###-####	(###) ###-####
Chief, Water Management	**********	(###) ###-####	(###) ###-####
Senior Forecaster	**********	(###) ###-####	(###) ###-####
Senior Forecaster	**********	(###) ###-####	(###) ###-####
Data Management	**********	(###) ###-####	(###) ###-####
Data Management	**********	(###) ###-####	(###) ###-####
Modeler	**********	(###) ###-####	(###) ###-####
Modeler	**********	(###) ###-####	(###) ###-####
Stream Gauging	**********	(###) ###-####	(###) ###-####
Biologist	**********	(###) ###-####	(###) ###-####
Chemist	**********	(###) ###-####	(###) ###-####
LRN Offices:			
District Engineer	**********	(###) ###-####	
LRN DPM	**********	(###) ###-####	
OC – Chief	**********	(###) ###-####	
OC - Environmental	**********	(###) ###-####	
NEPA Coordination	**********	(###) ###-####	
Chief, EC Division	**********	(###) ###-####	
Chief, Civil Design Branch	**********	(###) ###-####	
Dam Safety Coordinator	**********	(###) ###-####	
Chief, Operations Division	**********	(###) ###-####	
Chief, Hydropower Branch	**********	(###) ###-####	
Chief, Navigation Branch	**********	(###) ###-####	
Chief, Natural Resources	**********	(###) ###-####	
WOL Project Manager	**********	(###) ###-####	
CEN Project Manager	**********	(###) ###-####	
Chief, Public Affairs	**********	(###) ###-####	
East Kentucky OM	**********	(###) ###-####	
EKY Power Plant Manager	**********	(###) ###-####	
WOL/P Superintendent	**********	(###) ###-####	
WOL/P Control Room	**********	(###) ###-####	
WOL/R Resource Manager	**********	(###) ###-####	
LAU/P Superintendent	**********	(###) ###-####	
LAU/R Resource Manager	**********	(###) ###-####	
Mid Cumberland OM	**********	(###) ###-####	
MCA Power Plant Manager	**********	(###) ###-####	
DAL/P Superintendent	**********	(###) ###-####	

DAL/P Control Room	**********	(###) ###-####	
DAL/R Resource Manager	**********	(###) ###-####	
COR/P Superintendent	**********	(###) ###-####	
COR/P Control Room	**********	(###) ###-####	
COR/L Lock Master	**********	(###) ###-####	
COR/R Resource Manager	**********	(###) ###-####	
CEN/P Superintendent	**********	(###) ###-####	
CEN/R Resource Manager	**********	(###) ###-####	
Nashville Area OM	**********	(###) ###-####	
NAS Power Plant Manager	**********	(###) ###-####	
OLD/P Superintendent	**********	(###) ###-####	
OLD/P Control Room	**********	(###) ###-####	
OLD/L Lock Master	**********	(###) ###-####	
OLD/R Resource Manager	**********	(###) ###-####	
JPP/R Resource Manager	**********	(###) ###-####	
CHE/P Superintendent	**********	(###) ###-####	
CHE/L Lock Master	**********	(###) ###-####	
CHE/R Resource Manager	**********	(###) ###-####	
West Kentucky OM	**********	(###) ###-####	
WKY Power Plant Manager	**********	(###) ###-####	
BAR/P Superintendent	**********	(###) ###-####	
BAR/P Control Room	**********	(###) ###-####	
BAR/L Lock Master	**********	(###) ###-####	
BAR/R Resource Manager	**********	(###) ###-####	
KY Lock Resident Engineer	**********	(###) ###-####	
KY Lock Field Office	**********	(###) ###-####	
KY/L Lock Master	**********	(###) ###-####	
WOL Resident Engineer	**********	(###) ###-####	
WOL Field Office	**********	(###) ###-####	
CEN Resident Engineer	**********	(###) ###-####	
CEN Field Office	**********	(###) ###-####	
LRD Offices:			
Division Engineer	**********	(###) ###-####	
Deputy Division Engineer	**********	(###) ###-####	
Chief, Water Management	**********	(###) ###-####	(###) ###-####
Senior Hydraulic Engineer	**********	(###) ###-####	(###) ###-####
Regional WCDS Manager	**********	(###) ###-####	(###) ###-####
Hydraulic Engineer	**********	(###) ###-####	
Hydraulic Engineer	**********	(###) ###-####	
IM Specialist	**********	(###) ###-####	
OC – NEPA	**********	(###) ###-####	
Dam Safety Coordinator	**********	(###) ###-####	
Environmental Business Line	**********	(###) ###-####	

HQ Offices:			
H&H COP	**********	(###) ###-####	
Water Quality	**********	(###) ###-####	
LRD RIT	**********	(###) ###-####	
HQ UOC	**********	(###) ###-####	
TVA Offices:			
Knoxville:			
Manager River Forecasting	**********	(###) ###-####	
Lead Engineer Assignment	**********	(###) ###-####	
Preschedule Assignment	**********	(###) ###-####	
Hydrothermal Modeling	**********	(###) ###-####	
Navigation	**********	(###) ###-####	
Chattanooga:			
Daily Scheduling	**********	(###) ###-####	
Environmental Compliance	**********	(###) ###-####	
Gallatin Fossil Plant:			
Plant Manager	**********	(###) ###-####	
Navigation/Coal Handling	**********	(###) ###-####	
Engineering Manager	**********	(###) ###-####	
Cumberland Fossil Plant:			
Environmental Specialist	**********	(###) ###-####	
Engineering Manager	**********	(###) ###-####	
Plant Operations	**********	(###) ###-####	
National Weather Service			
ORFC Service Hydrologist	**********	(###) ###-####	
LMK Service Hydrologist	**********	(###) ###-####	
JKL Service Hydrologist	**********	(###) ###-####	
OHX Service Hydrologist	**********	(###) ###-####	
PAH Service Hydrologist	**********	(###) ###-####	
Power:			
SEPA Hourly Scheduling	**********	(###) ###-####	
SEPA System Operations	**********	(###) ###-####	
SEPA Operations Center	**********	(###) ###-####	
Sherman Cooper Power	**********	(###) ###-####	
Navigation:			
Coast Guard – Paducah	**********	(###) ###-####	
Coast Guard – Nashville	**********	(###) ###-####	
LRL–Chief, Operations	**********	(###) ###-####	
LRL–Chief, Tech Support	**********	(###) ###-####	
LRL-Chief, Maintenance	**********	(###) ###-####	
LRL-L/D 52 Project Manager	**********	(###) ###-####	

LRL-Operations Manager	**********	(###) ###-####	
Smithland Lock Master	**********	(###) ###-####	
L&D 52 Lock Master	**********	(###) ###-####	
L&D 53 Lock Master	**********	(###) ###-####	
Water Quality:			
USFWS (Cookeville)	**********	(###) ###-####	
KDOW – Technical Manager	**********	(###) ###-####	
KDOW – Water Sampling	**********	(###) ###-####	
KDFWR – Water Quality	**********	(###) ###-####	
TDEC – Technical Manager	**********	(###) ###-####	
TDEC – Permits	**********	(###) ###-####	
TWRA – Technical Manager	**********	(###) ###-####	
Fish & Wildlife:			
USFWS – Regional Manager	**********	(###) ###-####	
USFWS – WOL Hatchery	**********	(###) ###-####	
USFWS – DAL Hatchery	**********	(###) ###-####	
KDFWR – Fisheries Director	**********	(###) ###-####	
KDFWR – Trout Coordinator	**********	(###) ###-####	
KDFWR – Regional Biologist	**********	(###) ###-####	
TWRA – Fisheries Director	**********	(###) ###-####	
TWRA – Trout Coordinator	**********	(###) ###-####	
TWRA – Regional Biologist	**********	(###) ###-####	

3.3. Decision Making Protocol. The intended purpose of this interim operating plan is to identify potential water management conflicts and outline how the Cumberland River Basin reservoir system would be operated to best address these issues. It is not reasonable to expect, given the inherent uncertainty associated with weather and related hydrologic conditions, that specific water control decisions can be made well in advance. Rather, this plan will provide LRN Water Management with an approved operational guide from which day to day water control decisions can be made. When water becomes short and water management actions become particularly contentious it may become necessary to elevate certain decisions. This will be done through application of existing protocol where established chain of command is followed. The nature of water management is that decisions have to be made quickly. There simply isn't the luxury of time in many scenarios. Whenever LRN Water Management recognizes or otherwise is made aware of the sensitive nature of certain water control actions they will concurrently raise the issue to LRN Senior Staff and LRD Water Management (for coordination with LRD Senior Staff) for resolution. LRN Water Management will serve in an advisory, information providing role to support the decision making process. Once the decision is made LRN Water Management will be tasked with its implementation and subsequent tracking and evaluation.

4. References

Cumberland River Basin Master Water Control Reference Manual. U.S. Army Corps of Engineers Nashville District. Nashville, 1990.

Cumberland River Basin Master Water Control Plan. U.S. Army Corps of Engineers Nashville District. Nashville, 1998.

Cumberland River Basin Barkley Water Control Manual. U.S. Army Corps of Engineers Nashville District. Nashville, 1998.

Cumberland River Basin Cheatham Water Control Manual. U.S. Army Corps of Engineers Nashville District. Nashville, 1998.

Cumberland River Basin Old Hickory Water Control Manual. U.S. Army Corps of Engineers Nashville District. Nashville, 1998.

Cumberland River Basin Cordell Hull Water Control Manual. U.S. Army Corps of Engineers Nashville District. Nashville, 1998.

Cumberland River Basin J. Percy Priest Water Control Manual. U.S. Army Corps of Engineers Nashville District. Nashville, 1998.

Cumberland River Basin Center Hill Water Control Manual. U.S. Army Corps of Engineers Nashville District. Nashville, 1998.

Cumberland River Basin Dale Hollow Water Control Manual. U.S. Army Corps of Engineers Nashville District. Nashville, 1998.

Cumberland River Basin Wolf Creek Water Control Manual. U.S. Army Corps of Engineers Nashville District. Nashville, 1998.

Cumberland River Basin Laurel Water Control Manual. U.S. Army Corps of Engineers Nashville District. Nashville, 1998.

Cumberland River Basin Drought Contingency Plan. U.S. Army Corps of Engineers Nashville District. Nashville, 1994.

Memorandum of Understanding (Operating Agreement) Between Corps of Engineers, U.S. Army, Tennessee Valley Authority, and Southeastern Power Administration, Department of Energy, With Respect to Operations of the Cumberland System Projects. 1984.

Amended and Restated Agreement executed by The United States of America Department of Energy acting through the Southeastern Power Administration and Tennessee Valley Authority and Tennessee Valley Public Power Association. 1997.